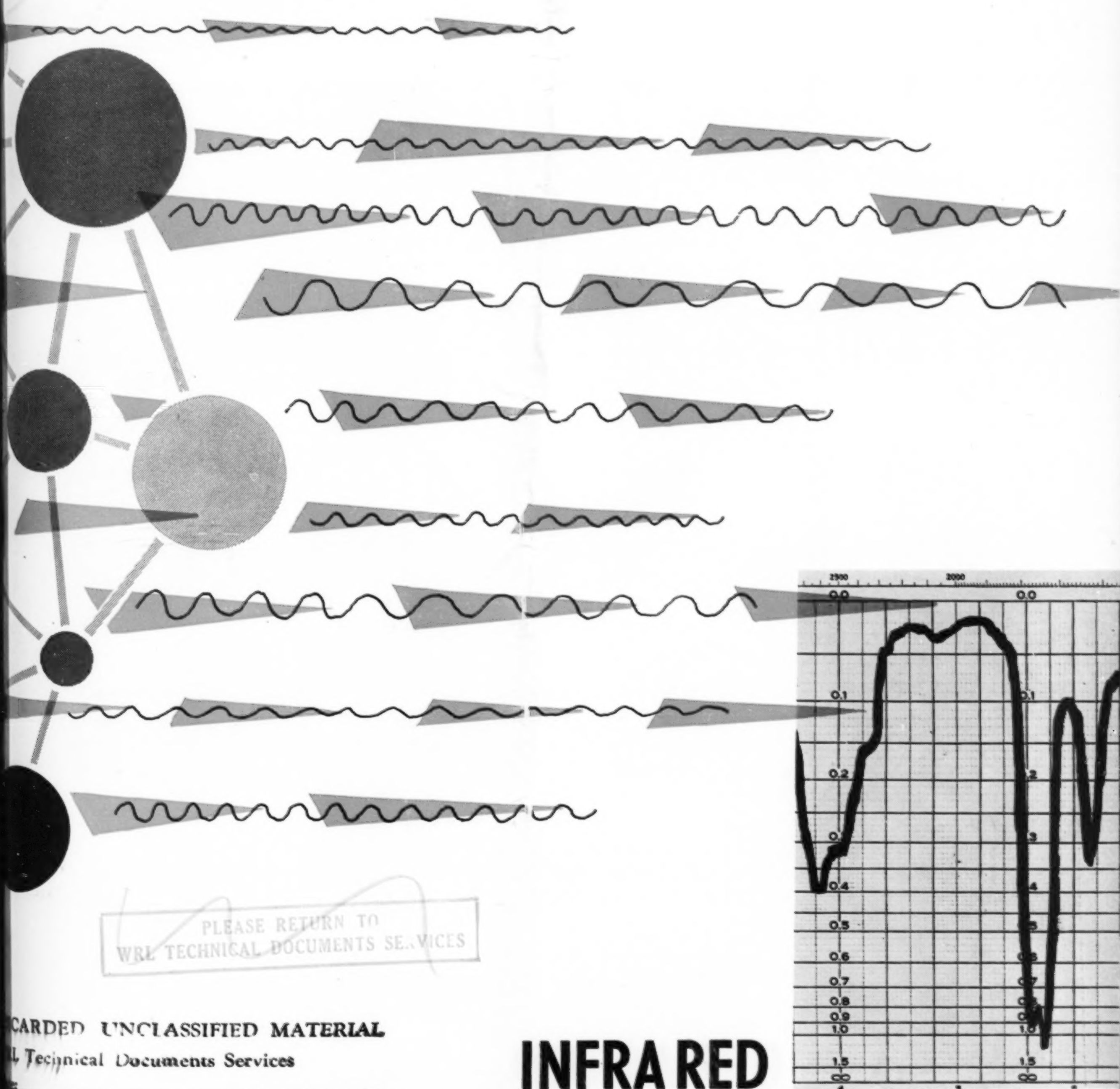
MAY 1957

Research & Engineering

The Magazine of
TECHNICAL MANAGEMENT

R/E



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electronics . . . catalyst for <u>industrial</u> progress

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To add a new dimension to the usefulness of electronically controlled power—in industry, medicine, research . . . RCA now presents a major "first" in electronic progress—a remarkable group of super-power tube designs capable of unleashing enormous amounts of high-frequency power *above and beyond all previous tube capabilities!*

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Visualized by the Radio Corporation of America as early as 1937 . . . and under a continuing development and field-testing program . . . RCA super-power tubes are now offered to progressive industries looking ahead to the practical application of super power in their future product planning. RCA is ready to discuss your present and future needs for super-power tubes. If *you* are ready, write today—to RCA, Tube Division, Commercial Engineering, Section E-84-Q, Harrison, New Jersey.

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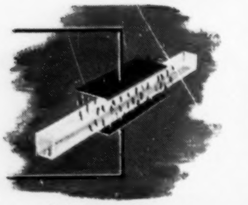
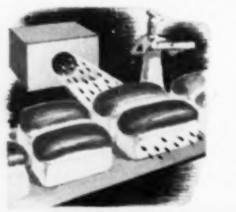
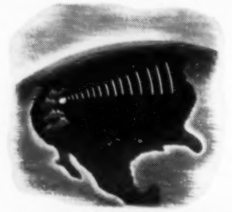


• Induction and Dielectric Heating

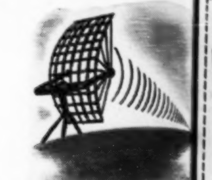


• Irradiation and Sterilization

• Radiology



• Communications and Scatter Transmission



• Radar

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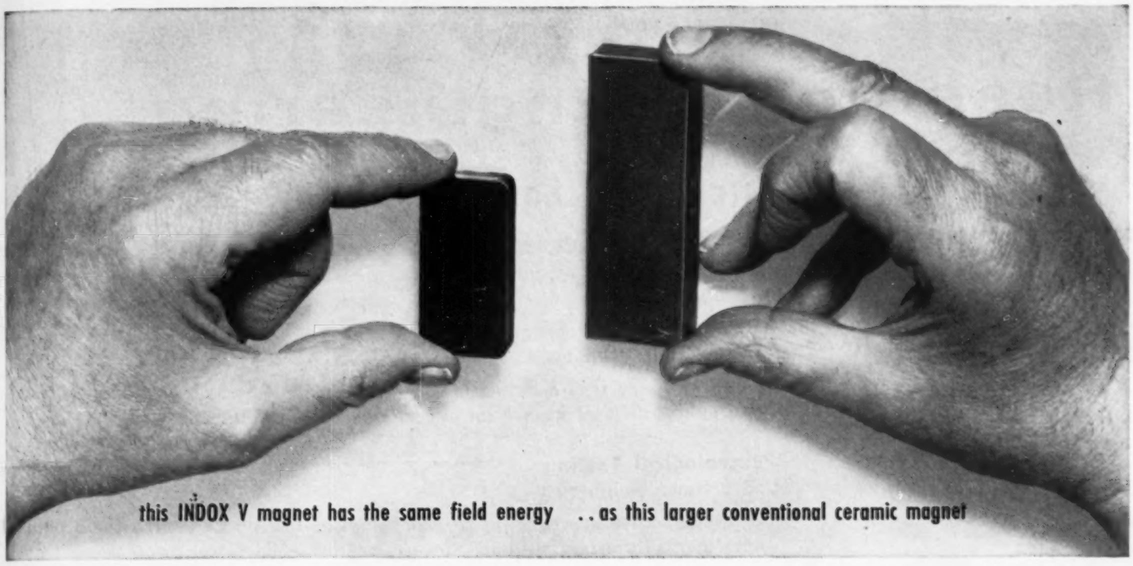

NEW, high energy Indox V ceramic permanent magnets

.. they're 3½ times stronger than conventional ceramic magnets

Indox V — another first from the research and development laboratories of The Indiana Steel Products Company — is available to magnet users *immediately*. This unique, new, magnetic material offers these important advantages . .

Indox V requires no critical materials. It is a highly oriented barium ferrite . . using inexpensive, noncritical, raw materials that are constantly available. Shortages in times of emergency cannot occur.

Indox V requires less space, weight to do same job. Volume and weight comparisons show that the energy of Indox V far exceeds Indox I . . and is comparable to Alnico V, the strongest permanent magnet material commercially available.

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JUST PUBLISHED! *This two-page data sheet gives detailed information on new high energy Indox V. Use this coupon to request your copy. Ask for Bulletin* **16-Q5.**

.. ideal for:

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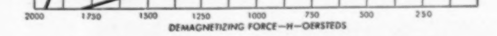

Comparison of demagnetization and energy product curve for conventional Indox I ceramic magnets and the new, high energy Indox V magnets.

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INDIANA PERMANENT MAGNETS

In Canada: The Indiana Steel Products Company of Canada Limited • Kitchener, Ontario

CIRCLE 2 ON PAGE 48 FOR MORE INFORMATION

Research & Engineering

The Magazine of
TECHNICAL MANAGEMENT

MAY 1957
VOL. III, No. 5

for MANAGERS of research
design
and development

BPA OVER 28,000 CIRCULATION

RESEARCH & ENGINEERING IS CIRCULATED TO MEN IN CHARGE OF INDUSTRIAL RESEARCH, DEVELOPMENT AND DESIGN DEPARTMENTS IN ALL BRANCHES OF INDUSTRY AND IN GOVERNMENT RESEARCH INSTALLATIONS. SUBSCRIPTION, U. S. A. AND CANADA, $10.00 ANNUALLY; OTHER COUNTRIES, $20.00 ANNUALLY; SINGLE ISSUE, $1.00 WHEN AVAILABLE. PUBLISHED MONTHLY BY THE RELYEA PUBLISHING CORPORATION. WILLIAM H. RELYEA, JR., PRESIDENT; EXECUTIVE, ADVERTISING AND SUBSCRIPTION OFFICE: 103 PARK AVE., NEW YORK 17, N.Y. LE -2-0541. EDITORIAL OFFICE: 77 SOUTH STREET, STAMFORD, CONN., FIRESIDE 8-7781. UNSOLICITED MANUSCRIPTS MUST BE ACCOMPANIED BY RETURN POSTAGE. ALTHOUGH ALL REASONABLE CARE WILL BE TAKEN, THE EDITORS ASSUME NO RESPONSIBILITY FOR THEIR SAFETY OR RETURN. ALL EDITORIAL COMMUNICATIONS SHOULD BE SENT TO THE STAMFORD OFFICE. PUBLISHED AND ACCEPTED AS CONTROLLED CIRCULATION PUBLICATION AT ORANGE, CONN. COPYRIGHT 1957, THE RELYEA PUBLISHING CORP. THE TRADEMARKS R/E AND RESEARCH & ENGINEERING ARE THE PROPERTY OF THE RELYEA PUBLISHING CORP., REGISTERED WITH THE U. S. PATENT OFFICE.

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Letters

Please send all letters to the editor to our editorial offices, 77 South St., Stamford, Conn. Correspondents should include their titles and company names. However, names will be withheld on request.

About Calculus

CHICAGO, ILL.

With reference to the book review, CALCULUS—A MODERN APPROACH, which appeared in February R/E . . . Mathematics, in common with most of our scientific disciplines, may be viewed from either of two viewpoints—that of scientific rigor and that of less rigorous utilitarianism. I do not dismiss the purely utilitarian approach, since most workers in this and collateral fields probably employ mathematics in this manner. But I feel . . . that mathematics, in common with other sciences, only grows and develops when treated with the greatest possible rigor.

[I think] . . . Menger has attempted to analyze some of the underlying concepts of the calculus, and, especially to differentiate clearly among the categories of *variables* which are generally lumped indiscriminately in standard references. Whether this leads to increased complexity is a matter of opinion; to me it appears that if valid distinctions can be demonstrated by such a treatment, then a clarification has been effected . . .

SIDNEY KATZ

Mr. Katz's premise, that "if valid distinctions can be demonstrated", does not necessarily yield his conclusion — "then a clarification has been effected"; obscure distinctions can be made. The point is rather that the distinctions in themselves be clear. This is Miss Hassler's point—the book is fine for those already skilled in calculus, but is less helpful to those who turn to it for basic instruction.—Ed.

Obstacle Course

NEW YORK, N.Y.

Prof. Freudenthal's article, THE CONCEPTUAL OBSTACLE COURSE, is a wonderfully clear description of many of the pits into which a person responsible for formulating research programs can fall.

I would like to add a few thoughts . . . to his statement that we should develop young people with minds trained in critical and independent thinking. We must be aware that such independent thinking will in many instances lead to unconventional thoughts and concepts. While we welcome these thoughts in technical matters . . . as the basis for important further steps in scientific development, we are all too often mortally afraid of unorthodox thinking in social and political matters. I do not believe the human mind and personality can . . . work in complete independence in one realm and complete conformity in another. The price society has to pay for the independent thinker in scientific questions is to accept the independent ideas and concepts in other matters . . . Just as we rely on the young person to arrive eventually by thought and experience at a sound approach and method in scientific matters, and do not hold against him, detours which he may have made so we should allow the scientist similar detours in other matters . . . The work of the public or private anti-intellectual committees that pretend to do a public service by probing into the past of scientists for possible "deviationism" during their young years is public knowledge.

V. PASCHKIS
DEPT. OF MECHANICAL ENGINEERING
RESEARCH LABORATORIES
COLUMBIA UNIVERSITY

NATICK, MASS.

I enjoyed Dr. Freudenthal's article . . . more than I can say. It is most refreshing to find such a clear and concise analysis of the many traps and obstacles in the gap between recognition of the existence of some sort of problem and the development of a solution.

ROBERT L. WOODBURY
SUPERVISORY RESEARCH
OPERATIONS ANALYST
OPERATIONS PROGRAMMING OFFICE
TEXTILE, CLOTHING & FOOTWEAR DIV.
U. S. ARMY R/D COMMAND

NOTE

The photographs used to illustrate Education for Engineering—U.S.S.R. (April R/E, page 12) were furnished by Sovfoto, New York City.

Reactions

SYDNEY, N.Y.

. . . Let me congratulate you on the production of an outstanding publication. It is one of the few magazines of a technical nature that I actually look forward to receiving and reading . . . My strong suggestion is that you exert all possible influence to prevent this magazine from growing any larger than it is. Too many good magazines, in my opinion, are ruined by expanding the content to a point where it is too much to digest in the rather limited time available . . . I realize that advertising content must grow to provide financial security . . . but keep the number of articles as they are.

CHARLES V. BRACK

MURRAY HILL, N.J.

I have read your article, MAKING THE MOST OF COMMITTEES by Scott Nicholson, in the March issue of R/E, and have found it most interesting and helpful.

JOHN M. SHRIVE
MURRAY HILL LABORATORY
BELL TELEPHONE LABORATORIES, INC.

VAN DYKE, MICH.

I enjoyed TECHNICAL MANAGEMENT in February R/E very much. The thinking was good and with this letter, may I encourage you to continue writing articles in this field.

L. T. SZADY, P.E.
VICE PRESIDENT
IN CHARGE OF ENGINEERING
FORMSPRAG COMPANY

AKRON, OHIO

Your article entitled CREATIVE ENGINEERING—APPLIED, by Alexander C. Wall, was very beneficial to us in the material presented. We believe that Mr. Wall's classification of three categories of Creativity to be a valuable concept in terms of our Work Simplification program. We would like to use this material in our training sessions.

GLENN R. COWAN
WORK SIMPLIFICATION DEPT.,
THE B. F. GOODRICH CO.

CLEVELAND, OHIO

I am especially interested in THE KLUGEMACHER'S DILEMMA, by Anthony Blundi. I would appreciate your conveying to Mr. Blundi my compliments on one of the finest examples of satirical writing I have ever read.

R. K. CULLER, MGR.
INSTRUCTION BOOK DEPT.,
CLEVELAND DIESEL ENGINE DIV.
GENERAL MOTORS CORPORATION

TECHNICAL MANAGEMENT

Merritt A. Williamson

School's Out – Training Possibilities

Spring is with us once again, and to each of us this means something different. To me, it signifies the first spring since my student days that has found me in the environment of a university. I've been looking forward to spring in academic surroundings all winter. I have wanted to write a column on university life so that perhaps some of my readers might decide, as I have done, to take the big plunge into teaching. We need good engineering teachers and school administrators: we need them badly. I'm sure you would agree with me that there's no more worthwhile activity than educating and training our youth.

How Have We Done?

But spring also means a time to measure the progress of plans that we formulated in the early months of the year. How far along have we come? In R & D laboratories, there is usually a flurry of activity in spring. Government money needs to be committed, and everyone is busy claiming his share of recognition and support. Spring fever abounds in this season. Somehow the desk piles higher and higher with literature to read, letters to answer, and plans to be made. It is so easy to give up and look out the window, or just wander about talking with people. Everyone survives spring somehow, but it is a disconcerting time of year since there is real work to be done and decisions must be made, even in the midst of distractions.

The Recruiting Season

It is too late, of course, to start plans to capture any of the college graduates this June, but it's not too late to set up appointments with next year's seniors. It's essential to do this now; otherwise all the select appointments will be filled.

Perhaps now is the time to take stock of your college recruiting plans to see how they could be improved. Are your recruiters doing their jobs? What sort of persons did they recruit this year? Were they in a class with last year's group? What institutions have prepared your men the best? Would you be wasting your time visiting the second-rate schools again? Have you made certain that the students have received all the really pertinent information about the company? Is the recruiting literature designed to make students want to work for your company? Should you leave the job of getting new employees to recruiters or should you put your own technical men in the act?

Summer Help

Another set of decisions soon to arise will be the question of summer technical help. This help falls in three general classes.

The first class of summer worker is the college junior or sophomore. Anxious to increase his knowledge in the area of his major interest, he will probably require a great deal of someone's attention in answering his questions. In his first summer with the company he probably will bring no monetary return to the company. If the same student returns for a second year though, the initial investment may be recovered.

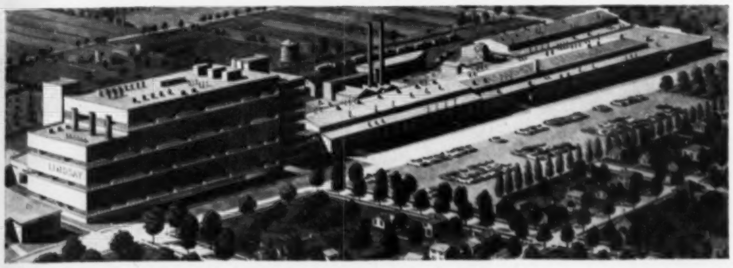
There is always the temptation to give these young men routine assignments to conserve the time of the technical staff. The greater the urgency of the projects on hand, the less chance a summer employee will have to participate. But routine assignments are what the student abhors. In fact, such assignments will drive him to another company next year. If the college student has any promise, he is going to ask questions. He is going to take every opportunity to check what he has learned from the books. This could be good for him as well as for the staff. Some worthwhile and novel ideas may actually emerge.

(Continued on page 8)

Want a Carload of Rare Earths?

They're available for prompt shipment in a gram to a carload

a report by LINDSAY



Back in the early 20's, it would never have occurred to us that in a few years we would be shipping rare earth salts in carload quantities for a surprising variety of chemical and industrial applications.

For a long time, as you may know, the rare earths were simply a by-product of our regular business of producing thorium nitrate for gas mantles. Up to 35 years ago, rare earths were little more than scientific curiosities. Industry had not yet discovered them as a practical scientific tool.

But, as time sped by, we learned more about these unusual elements and how to produce them in larger quantities, in higher purities and at lower cost. And with their increasing availability, industry began to find ways to use them profitably in their operations. In the last ten years, we've seen a sharply increasing rise in the demand for rare earths from a rather amazing variety of industries.

WHY THIS DEMAND? Well, as we see it, it's due largely to the enormous technological strides made since World War II. Industry itself sparked much of this interest by its own explorations of the rare earth group in a search for materials to improve products and processes. Their studies in relation to specific problems often uncovered totally unsuspected applications. It was a sort of chain reaction that is still increasing in velocity.

LINDSAY BUILT NEW PLANT. We saw what an industrial revolution the rare earths were creating. And anticipating heavy demands, we constructed our modern plant in 1953. The Lindsay plant facilities, including more recently developed and improved separation processes (such as our ion exchange systems), increased our production capacity manyfold.

WHAT ARE THE RARE EARTHS? Rare earths are *not* rare—nor are they earths. This group of 15 elements (atomic numbers 57 through 71) are trivalent metals found together with thorium and yttrium primarily in monazite ore. In chemical properties they are almost identical, a fact which makes them difficult to separate and at the same time makes them valuable tools for research and industry.

HOW THEY ARE USED. The fascinating description of industrial applications of the rare earths would fill many books. We work with these materials every day and we're constantly amazed at the variety of ways in which they're used. Here are only a few. Glass polishing. Steel additives. Catalysts. Colorizer and decolorizer for glass. Medications. Ultra-violet light absorber. Arc carbon electrode cores. Aluminum and magnesium alloys. Lighter flints. Radiation-proof glass. Waterproofing. Textile production. Color TV tubes . . . and the list goes on and on.

RARE EARTH SALTS. Lindsay produces rare earth salts in large tonnages and in varying purities. Most of them are surprisingly low in cost. Rare earth chloride—for example—a mixture of several of these elements—is only about 25¢ a pound and available in virtually unlimited quantities. High purity separated rare earths are, of course, more expensive, but economical in relation to the wonders they perform.

HUGE SOURCE OF SUPPLY. To keep up with the demand and assure industries of a steady supply, we maintain in our plant a stockpile of monazite that is now 24,000,000 pounds. And we're constantly prospecting in various parts of the world for this miracle ore—source of the versatile rare earths.

WORTH INVESTIGATING. Your research people may find it rewarding and profitable to study the possibilities of the application of rare earths to your own products and processes. We will be happy to supply pertinent data and to make available to you the help of Lindsay's technical staff.

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

274 ANN STREET • WEST CHICAGO, ILLINOIS

TECHNICAL MANAGEMENT *(Cont. from p. 6)*

The High Schooler

A growing class of summer employee is the high school student. Many civic groups are interested in seeing that our pre-college students are given actual industrial experience. Communities sometimes stipulate that these students be given something worthwhile to do and not be assigned as a routine messenger boy or stock clerk. Work should be in some professional area in contact with university people so that the student will be stimulated to go on to college. It is a real problem to place him in an organization where he can help trained scientists and engineers with their work. It takes a peculiar type of planning skill to keep these persons busy on projects which are worthwhile for themselves as well as for the company. Here, again, if the student is curious, a lot of industrial time will be spent educating him.

An Obligation to Educate

Of what value is the summer employee to the company? His tenure is so brief that the jobs assigned must, of necessity, be rather simple. There is hardly time to teach a complex job in a three month period. The jobs are therefore apt to be both simple and limited. The summer employee is not apt to learn as much from these assignments as he hopes. If he is assigned as a member of a project team, the management must be prepared to spend unproductive time explaining items and giving background data on problems. This may take weeks or months depending on the teacher and the complexity of the problems involved.

On the other hand I feel that industry must recognize its obligation to educate. Universities can't, with the demands made upon them, do the complete job, or even as thorough a job as they did twenty years ago when technology was changing less rapidly. I would be very much interested in what plans your companies have for the employment of these individuals. It is a distinct obligation today; and if we can evolve worthwhile procedures, we can help our country tremendously.

Teachers in Industry

A final, and very useful, extra hand in the summer is the high school and college science teacher—the faculty member who works for three months in industry between school terms. Work of this sort gives him a chance to keep up-to-date technically and to earn some extra money. Industrial experience makes him a better teacher, and adds interest to his courses. His students like to know that their teacher has been out of the ivy tower and knows the latest practices in the field.

The Junior High Student

Exactly a year ago I received a letter from Fred H. Frost, the Research Director of S. D. Warren Company, Cumberland Mills, Maine and I have held it until now. He writes:

"I had an unusual experience last week. An eighth grader called me and explained that he had just finished his "career assignment" and that he had chosen Chemical Engineering. He asked if I would be good enough to read and comment on his report.

"I enclose excerpts from his thesis. Coming from a thirteen year old I thought this was really remarkable. He did this without help or advice.

"I thought you might be interested in publishing his list of qualifications for a Chemical Engineer. If others get the same lift as I did knowing youngsters like this are on the way up it should be well received. The boy's name, I think, should be left out—his I.Q. is 164."

Introduction

The youngest of the recognized major divisions of engineering, chemical engineering, has many great achievements to its credit. As in other branches of engineering, some of the achievements had their prototypes in the old days of alchemy, but the scientific treatment of recent decades has enhanced their value.

Chemical engineering covers manufactures of organic industries, such as rayon and leather substitute, drugs, and cellulose, explosives; heavy chemicals; paper; soap; foods, such as sugar, cereals, fruit preservation, and artificial fats, fuel industries; gas plants; petroleum and tar products; paints, varnishes; glass industries; and fertilizer.

I chose this field because there are so many industries in need of chemical engineers and it serves my country well, also, it will greatly improve my own personal growth.

Use of Chemical Engineering to the World

The following are some of the most notable of the chemical engineer's contributions to mankind.

1. The LeBlanc and Solvay processes for making soda from common salt.
2. The commercial synthesis by Haber of ammonia through the fixation of atmospheric nitrogen as a basis for fertilizer and explosives.
3. The perfecting of petroleum oil cracking which greatly increased the yield of gasoline from petroleum and the improvement of gasoline for internal combustion engines.
4. The Sabatier process for hydrogenating unsaturated oils to make edible fats from inedible vegetable oils.
5. The conversion of cellulose from wood and cotton into lacquers, plastics, and explosives.
6. The hydrogenation of coal and heavy oils to produce gasoline.
7. The development of modified cellulose to produce textiles such as rayon and cellophane, and of noncellulose materials to produce nylon and similar materials.
8. The discovery of the phenol-formaldehyde plastics (such as Bakelite) which established the plastics industry.
9. The production of potash from brines and impure salt deposits for artificial fertilizers.
10. The quantity production of magnesium and bro-

mine from sea water yielding strong lightweight metal and alloys and facilitating the manufacture of ethyl lead.

11. The development of synthetic resins, largely from tar and petroleum, from which durable coatings, bristles, and fabricoids are made replacing natural gums.
12. The production of synthetic rubber substitutes from gasoline and alcohol.
13. Improvements in glass manufacture for improved light bulbs, duraglass, fiberglas, pyrex, and glass with special optical properties.
14. The high pressure technique for converting simple gases, such as carbon monoxide and dioxide and hydrogen, into wood alcohol for industrial uses.

How this occupation can add to my own personal growth

In the chemical engineering profession there is much opportunity for personal growth. There are nine ways in which a chemical engineer can become a leader.

1. Determination

This is the quality of character that drives a leader on to his goal no matter what difficulties he encounters.

2. Self-Confidence

The chemical engineering profession will boost self-confidence. If a man does not have self-confidence, he can be sure that others will place no confidence in him.

3. Courage

This quality is akin to determination and self-confidence yet is quite different. Both physical and moral courage are required. No coward can lead.

4. Responsibility

This essential quality of leadership is in some respects similar to integrity and in some respects different. The leader must be eager to accept responsibility.

5. Energy

In general, people are lazy and indolent. Many persons of greater ability are willing to submit to a leader because of sheer laziness. The chemical engineering profession builds energy and rules out laziness.

6. Skill in Human Relations

This knowing how to get along with people is very important to those engineers who strive for executive positions.

7. Ability to express one's thoughts

The great number of reports needed in chemical engineering sharpens this ability and makes him easily understood by the layman.

8. Integrity

This quality is probably the most valuable of personal qualities. The factor that most commonly distinguishes the outstanding executives is their personal integrity and loyalty.

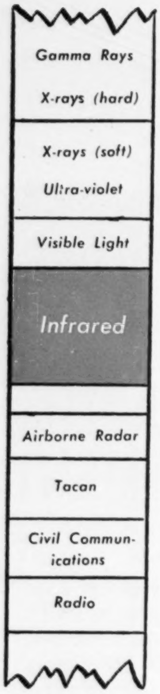
9. Technical Ability

This essential quality of leadership is perhaps the least important of the nine. It is, however, essential: do not assume that the heights of leadership in chemical engineering can be reached without it.

What program do you have to encourage the secondary school student, the college student, and/or the teacher—either local science teacher, or university professor? How

(Continued on page 37)

The sensitive fingers of infrared are only now finding extensive use in industry and the military. Yet it is the fruit of 150-year-old basic research. R/E presents an expert's view of an exploding field.



INFRARED

the frontier frequency

by Van Zandt Williams

WHILE NUCLEAR FISSION and tranquillizing drugs capture headlines, a quieter scientific evolution is having equally far-reaching effects in the world. Since World War II, infrared has developed into an invaluable tool for industry and medicine, and into a new weapon for the military arsenal.

The use of infrared radiation is an evolution and not a revolution because infrared has been known and studied for 150 years. Infrared is a radiation phenomenon as are x-rays, visible light, radar, and radio; but it has two unique characteristics. It is a handle by which the chemical or biological researcher can quickly determine and measure the organic chemicals in a test tube, biological system, or continuous process pipe. It provides quick knowledge by which a new material can be discovered, a reaction controlled. For the military, infrared detects and measures the temperature of a near or distant object. Military targets—tanks, planes, power plants, factories and even man himself—have temperatures higher than their background. That heat is a means of detecting a target and directing a homing missile. Because of its analytical and measuring attributes, infrared is vital for all aspects of industrial or military effort.

A few examples will illustrate its broad usefulness:

Applications:

In Chemical Research, Infrared was a basic tool in determining the structure of penicillin and in guiding the synthesis of the arthritis palliative, cortisone.

In Chemical Product Control, Infrared measures the optimum harvest point in penicillin fermentation, specifies ethylene purity for polyethylene polymerization, and monitors aromatic recovery in the coke industry.

In Chemical Processing, Infrared continuously measures isobutane in petroleum alkylation and carbon monoxide.

In Automotive Research, Infrared studies reactions in combustion cylinders and measures exhaust gases for efficiency and air pollution.

As a safety device, infrared automatically records concentrations of explosive gases—sniffs breaks in gas mains.

In Metallurgy, infrared measures temperature in furnaces and continuously monitors organic coatings on cans.

In Pollution detection, infrared measures hydrocarbons and carbon monoxide in air and submarines to ppm.; and detects phenol, oils and detergents in water pollution.

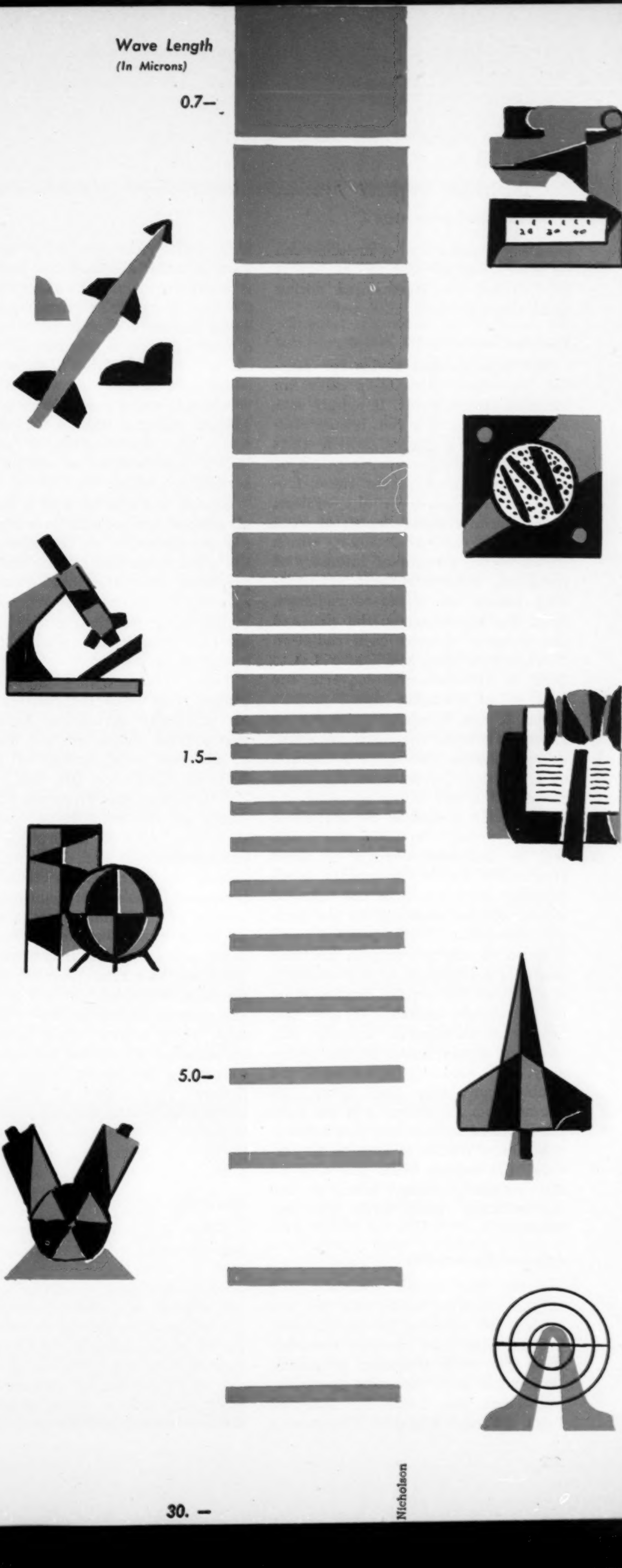
In Biological studies, infrared identifies bacterial and virus strains.

For the military, infrared measures temperatures in jet engines. It is used in aerial reconnaisance and fire control. It is basic in homing missiles and the Snooperscope.

In Criminology, infrared matches materials at the scene of the crime to those in criminal's possession.

Finally, infrared evidence is accepted as proof of identity in patent claims.

Infrared is the portion of the electromagnetic spectrum starting at the deep red, the limit of the eye's sensitivity (hence its name) and extending out to the microwave or very short radar region. It is characterized by a wavelength unit, the micron, about 1/50,000th of an inch long. The visible region starts with the violet, about 4/10ths of a micron in wavelength and extends to the red, about 7/10ths of a micron. Infrared then extends from 0.7μ out to about 200μ although the most useful region chemically is from 2.5- to 15μ and militarily from 0.7 to 12μ. Light radiation is a wave motion and for every wavelength of infrared there is a corresponding frequency of motion—the number of vibrations of the wave in a second. The product of a radiation wavelength (λ) times the radiation frequency (ν) is the familiar constant c, the velocity of light ($\lambda\nu = c$). It is perhaps easiest to understand the usefulness of infrared to the chemist by discussing infrared radiation in terms of its frequency rather than its wavelength.



What is Infrared?

All molecules are made up of atoms connected by chemical bonds which act very much like springs. These atoms or atom groups are in continuous motion with respect to each other; and each molecule has definite vibration frequencies for these motions. Two identical molecules have the same atom pattern and have the same set of vibration frequencies; but two different molecules have different sets of frequencies. These various frequencies have the same range of values as the frequencies of infrared radiation. If infrared radiation of a frequency ν_1 strikes a sample whose molecules have a vibration frequency ν_1 resonant energy exchange takes place—the infrared radiation is absorbed and disappears. If infrared radiation of some other frequency ν_2 strikes the sample that does not have a corresponding vibration frequency, the radiation passes through unaltered. Thus the characteristic me-

(Continued on next page)

(Continued from page 11)

chanical vibrations of a molecule can be determined by passing through it all infrared frequencies and noting those that have been absorbed.

How the Spectrometer Works

The experimental device for making such measurements is called an infrared spectrometer. It simply consists of a source; a rod, heated electrically to about 1200°C, which emits all infrared frequencies; a prism or grating, which disperses these frequencies in space; a slit system, which permits the isolation of each frequency; and a detector, which measures the amount of intensity of radiation. The instrument automatically passes the dispersed radiation from the source across the slit, and the detector absorbs each radiation frequency in turn, and converts it to heat. A thermocouple converts the heat to an electrical signal proportional to the intensity of radiation from the source. The electrical signal drives a stylus. The result is a graph of frequency (or wavelength) along the abscissa and intensity along the ordinate. If a sample is introduced and the process repeated, the graph will be the same—except at those frequencies where the sample is vibrating, in which case the detected signal will be weakened by the sample absorption. With point-by-point division of the two graphs, the final result is a *spectrum of the sample*—a graph of the percent transmission of the sample against infrared frequency or wavelength. Actually, this two-step measurement is not necessary. All modern instruments are double-beam; i.e., they carry two beams from the source and the sample is placed in only one. The spectrophotometer measures both beams, divides the sample beam intensity by the reference beam intensity and automatically plots ratio vs. frequency.

Infrared Fingerprints

From this simple understanding of the spectrum is derived the usefulness of infrared to the chemist.

First, since two identical materials have the same vibration frequency, they must give the same spectrum: and since two dissimilar materials have different vibration frequencies, they must yield dissimilar spectra. Thus a material's infrared spectrum is a fingerprint of that material; and the matching of the infrared spectrum of an unknown sample with that of a known sample is accepted as chemical proof of identity. With over 1,000,000 different known chemical compounds and a good library of pure spectra (single, unique characteristics), the identification of an unknown has become a simple IBM sorting procedure.

Second, the spectrum of a mixture of several components is essentially the superposition of the spectra of the pure components with allowance for their concentrations. Thus, not only can the components of a mixture be identified, but their concentrations can be quickly and accurately determined as well.

Third, the spectrum of an unknown sample gives useful information about its molecular structure. Remember that organic compounds are made up of different combinations of atomic building blocks as OH, CH_3, NH_2, $C=O$, phenyl, etc. Since the building blocks are the same atomic patterns, these are infrared absorption bands characteristic of each building block. Hence, an infrared spectrum of a compound consists of bands characteristic of its building blocks as well as those characteristic of how the blocks are assembled. Inspection of an unknown spectrum permits an immediate statement of which blocks are present as well as which are absent, thus giving much immediate information about the unknown and narrowing the search in the spectral library. This aspect of infrared is particularly valuable in the intensive research on a competitor's sample brought in from the field by a salesman.

Discovery of Infrared

These are the research chemists' application of infrared. They are not new or sudden. Infrared was discovered in 1800 by an astronomer, Sir William Herschel, who measured the temperature rise in thermometers placed in the spectrum of the sun as dispersed by a glass prism. He found the temperature to increase from violet-red, but a much greater increase out beyond the red. The development of infrared has been difficult because good transmitting materials had to be found and sensitive thermocouples and bolometers for detectors had to be developed. As an example of the difficulty, the commonly used wide-range detector today is a thermocouple which must detect radiation causing a heat rise of one millionth of a degree and an electrical signal of less than one billionth of a volt. It took about a century to achieve reasonably useful equipment. During the thirties, the organic chemist started to exploit the tool and several progressive chemical and petroleum companies built equipment for chemical research.

World War II was the turning point in the use of infrared. The synthetic rubber program required rapid analysis of the C_4 fraction for butadiene production and since infrared was the best method, commercial instruments appeared in 1943-4. At that time, perhaps 40 homemade instruments were in use representing 140 years of endeavor. Today, the number is about 2500 and this chemical use is just in its infancy.

Wartime Background

For the military, the story is different. Infrared use appeared late in the war by Germany. The Allies made little use of the phenomenon, their equivalent development effort going into radar. The German effort was on equipment such as the Snooperscope—a device operating on the same principles as visible light, but of a wavelength just beyond the eye's sensitivity. In this sense, powerful search lights were used with special filters to remove the visible light. The targets were illuminated and the reflected light focused on a fluorescent image tube which showed a picture just as a television tube fluoresces from the electron beam. In its early use, this type of device was of great value: the Germans had complete control over Russian tank attacks supposedly secure in the darkness. However, with proper equipment, the radiation of infrared-filtered searchlights is as observable as visible light and its advantage is minimized.

No Warning Signals

Present military applications are

based on viewing the enemy target as a *heat* source and not as a source of light or reflected light. Academically, this is a bit of a quibble since we are discussing the same basic manifestation—electromagnetic radiation. Practically, however, there is a world of difference. The study of an enemy target at night by visible light, radar, or sound waves, is an *active* pursuit. One has to emit a radiation and then measure its reflectance by a target. The act of emittance gives the enemy warning of the detection and, in the case of radar, he can confuse the reflectance by jamming. Infrared, on the other hand, is a passive device. The enemy is detected by his own signal emission.

Here's how that's done. Any object at a temperature above absolute zero (and everything is) having an emissivity greater than zero (and everything does) gives off electromagnetic radiation according to Planck's Black Body Law. These radiations vary in intensity vs. wavelength according to the temperature of the emitting body, but any object at a temperature different from its surroundings will emit a different radiation from that of its surroundings. And so if sufficiently sensitive means of detection are available, an enemy target (which must consume power and therefore rise in temperature above its background) emits detectable radiation.

Photoconductive Conductors

The wide range thermal detectors used in chemical spectrophotometers have an efficiency at their limit of detectability of about 0.0001%. Since World War II, there has been intensive development of so-called photoconductive detectors. These detectors, often cooled to liquid nitrogen temperatures, can be made sensitive out to 6-7μ. Furthermore, they have a tremendous advantage over thermal detectors in that their speed of response to a radiation signal is very rapid. Thus they can be used from an airplane in a television-like scan of the ground temperature below or servo on a target with sufficient speed to keep a homing missile pointed. Any object that differs from its surroundings by so much as a few hundredths of a degree cannot be camouflaged from infrared detection. The importance of infrared from the military point of view of detectability and passivity is obvious.

Each of these applications, chemical and military, is showing appreciable growth. The business volume of infrared laboratory spectrometers today is running at the rate of $6- to $7-million a year. Principal suppliers in the United States are The Perkin-Elmer Corporation, Beckman Instruments, and Baird-Atomic; in England, Hilger-Watts, Unicam, and Grubb-Parsons; and in Germany, Leitz.

Industrial Uses

The chemical, petrochemical, petroleum, and pharmaceutical industries, and universities and hospitals, are relying increasingly on infrared. Here are a few examples:

Merck uses it for control of solvent purity; DuPont, for water in Freon; Bakelite, for unreacted phenol in phenol formaldehyde resins; General Motors for triptane; Atlantic Oil for analysis of oils and phenols in water effluents; Standard of Indiana for total aromatics in gasoline fractions, Picatinny Arsenal for TNT analysis; Naval Research Laboratories for analysis of base rubber in unknown compounds; Phillips Petroleum for measurement of crystallinity in polymers, etc.

These are routine bread-and-butter analyses—the money, manpower, and time savers. A similarly basic use is the provision of quick answers to the questions of the synthetic organic chemist—Are my initial reactants pure? Did I break the carbonyl bond in this reaction? Has the reaction gone all the way?

A more dramatic illustration is to watch a trained infrared spectroscopist analyze the infrared spectrum of an unknown compound to determine its identity. The identification of unknown materials is another prevailing use for infrared.

Up to the advent of infrared, such unknown identification had been a laborious procedure, consisting of many tests, which resulted in destruction of the unknown sample—often before the answer could be obtained. Now a trained man can, from the one non-destructive datum—the infrared spectrum—quickly find the major aspects of the unknown structure. This use of band identification so narrows the possibilities that matching the unknown spectrum to the limited spectral library is a matter of minutes.

Newer, Less Complex Devices

The customer list above emphasizes the larger sites because infrared spectrophotometers have been expensive and rather complex equipments requiring specialists to operate them. But within the last year, simple, inexpensive, easy-to-operate instruments have appeared. These bring the tool within easy budget reach of the one-man analyst companies and small universities. With these available, infrared spectrometry can now reach its potential value—the most useful of all methods of general chemical analysis.

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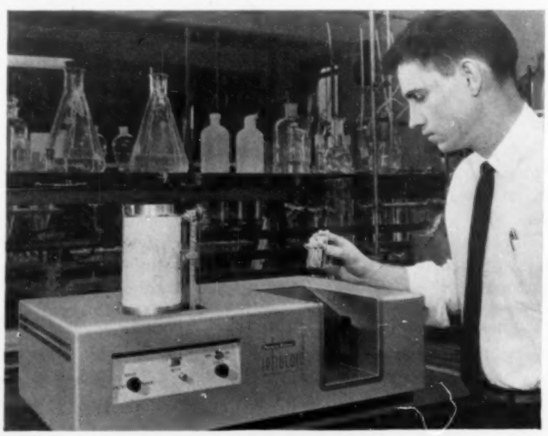

Representative of the trend toward putting the spectrophotometer into the hands of the practicing chemist is this model by Perkin-Elmer. Priced between $3-4,000, it has a spectral range of 2.5 to 15 Microns — the fundamental infrared region —and is capable of producing an analysis profile in 12 minutes.

INFRARED
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(Cont. from p. 13)

Automatic Process Control

These chemical analyses are batch analyses; which means that the sample must be brought to the instrument for study. This can be an expensive and time-consuming method if the sample is from a continuous chemical process. Why not take the instrument to the process, flow a bypass sample from the process stream through the instrument sample compartment, and measure chemical concentrations continuously? And if measurement is achieved, why not take the next step to automatic process control? It's easier said than done.

Here's why: the infrared principles are somewhat complex and experimentally difficult. The conversion of a laboratory instrument operated by an expert to a continuously working, unattended device is a major step. It is being tackled. Today, there are infrared process instruments of both the dispersive principle of the laboratory spectrometer, and of the non-dispersive type on-stream, in continuous operation. They are used by the petroleum industry in monitoring efficiency of fractionating towers; in the petrochemical industry for measuring methane and acetylene, and for warning of high CO and CO_2 concentrations on the catalyst in making ammonia. The atomic energy sites apply them for continuous measurement of heavy water in the 99.8- to 100% of purity range. IR process instruments are not yet in common use. Their application is too new. Nor are they applied to automatic control as much as to visual or alarm indication. But their future is certain. As the chemical and petroleum industry goes to full automation, it must do so on the basis of product concentration analysis, since that is

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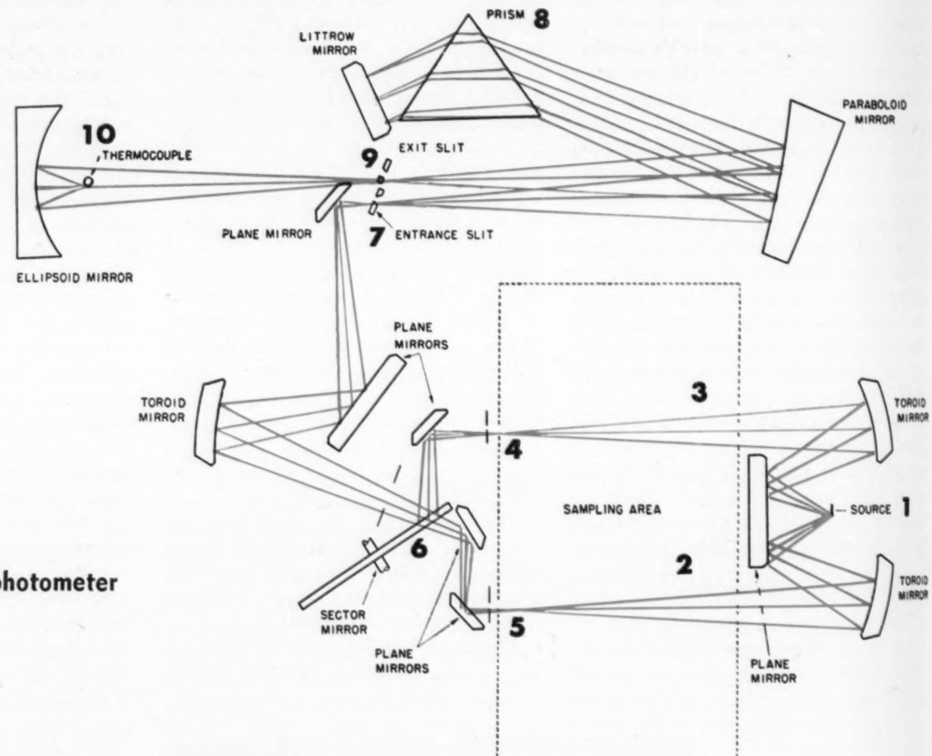
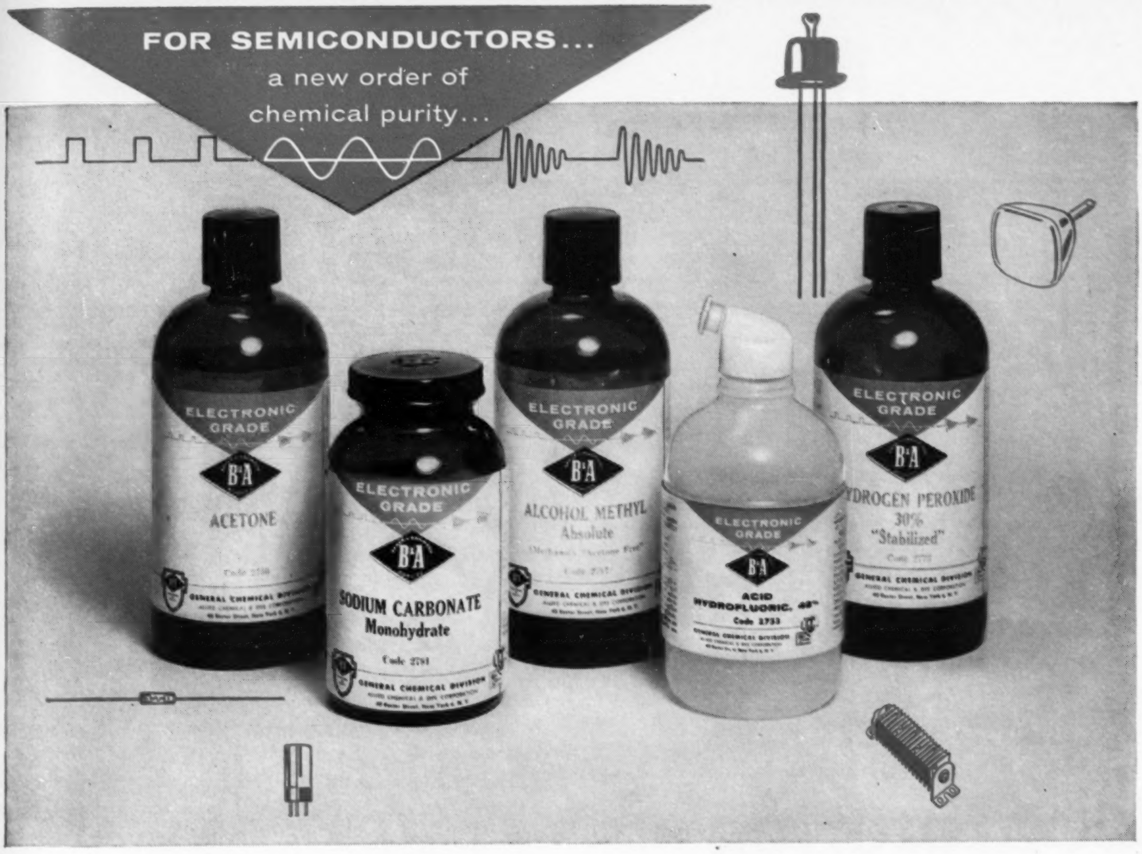


Optical Layout of Infrared Spectrophotometer

In this schematic of an infrared spectrophotometer infrared radiation from the source (1) is divided into two beams; the sample (2) and the reference (3) beams. The source is imaged at points 4 and 5. The sample is placed at point 5 and at point 4 an optical attenuator modifies intensity of reference beam to correspond to that transmitted through sample. The beams are combined by a rotating sector mirror (6) in such a way that radiation from the sample and reference beam is alternately directed to the monochromator through the entrance slit (7). The radiation passes through the prism, (8) is dispersed, is reflected back through the prism from the littrow mirror and emerges from the exit slit (9) to be condensed on the thermocouple (10). The presence of a sample at position 5 may cause a difference between energy transmitted by the sample and reference beams. Any differences will produce an alternating signal at the thermocouple (10), corresponding in frequency to the rotational frequency of the sector mirror (6). This signal is amplified and used to control a servo motor which moves an optical attenuator (4). The reference beam energy equals the sample beam energy. The position of this optical attenuator is, then, a measure of the sample transmission. A spectrum is recorded automatically when the wavelength is scanned.



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R/E reports

ARMOUR'S Industrial Research Conference

TO AN EVER INCREASING EXTENT, profit is becoming a main driving force in industrial research activity. This month in Chicago, Armour Research Foundation played host to several hundred research directors at a symposium centered on the subject "Research for Profit".

For the most part, the speakers were men who have devoted their lives to research and development in one form or another, and have watched research grow from an infant activity to an industry employing over 500,000 people. For example, Robert Semple started as a research chemist in the Monsanto Chemical Company; Clifford Rassweiler, Vice Chairman of the Board of Johns-Manville Corporation, has spent over 30 years in chemical research; Bennett Archambault, President of Stewart-Warner Corporation, headed up the European Theatre of the Office of Scientific Research and Development during World War II.

Here R/E presents some of the highlights of the papers which were presented at Armour's symposium.

Research—Key to Diversification

Hitting upon totally *new* product ideas often seems to be a matter of chance or accident. James H. Binger, Research Director of Minneapolis-Honeywell, pointed out, however, that these lucky breaks are not purely happenstance, but are the results of planning.

"Industrial researchers are not unlike the grizzled old uranium prospector out in our rugged western country," he said. "The prospector has a planned course of action, to be sure, but he doesn't arbitrarily chart a narrow course across a chosen area and follow it to the exclusion of looking elsewhere. Instead, he remains constantly alert to signs of deposits wherever they may be, and he does not hesitate to go off on side explorations if the signs look promising. Sometimes he strikes paydirt this way, and so do industrial researchers. When either meets success off the beaten path, you can certainly call it luck. But I submit that where lucky breaks occur with more than normal frequency, they are the

result of intention and willingness to be flexible, and a great deal of alertness."

Avenues Leading to New Products

How does a research and development department direct itself along a path that will turn up ideas for new products? Mr. Binger answers that there are a number of ways to start.

For instance, the company can chart a *general field* for exploration. Honeywell's general field is automatic control, Mr. Binger said. "Within the field we found it possible to generate a lot of diversification, both by product and by market. In some instances, we found we were going into activities outside the automatic control field.

"But by and large we found that automatic control, and its related problems, has a diversification potential more than adequate to challenge our available capital. The processing of diversified products is not uniform. It is solely researchers' responsibility."

Another route toward new ideas, Mr. Binger pointed out, is to apply known principles and devices to novel applications. For example, Honeywell's researchers found there was a need for manual control in the art of dry cleaning so they designed a control system patterned after the devices for accurate control of moisture in textile weaving rooms.

Another example of a new product developed from old principles, Mr. Binger said, was DIM-A-LITE, based on an auto-transformer device.

Exploration of Phenomena

Sometimes results flow from research work carried on to explore *phenomena*. Explained Mr. Binger, "In the case of a research investigation into the properties of flame, ideas were advanced for the development of a novel explosion warning device. We will spend some time and money on the development of this device and, if it works out, we'll soon have a new product whose birth can be traced to research investigation of an apparently unrelated problem."

Sometimes ideas originate in a development group having no direct contact with that product's market. One of Honeywell's engineers conceived the idea that a magnetic device sensitive to the presence of ferrous materials would be useful in highly automatic transfer machine lines in the automobile industry. "It is interesting to note," said Mr. Binger, "that electrohydraulic valves, electropneumatic valves and tracer systems grew out of a study by a manufacturing department of the possible machine shop uses for advanced servo techniques developed for other aeronautical purposes."

Frequently, a new product results from efforts to help manufacturing. For example, Honeywell needed a special rubber impervious to aircraft fuels for sealing fueltank measuring units. Rubber suppliers were not able to supply it. But Honeywell's rubber and plastic laboratories succeeded in finding an answer. It now produces various formulations of this rubber for its own use.

"These breaks may appear to be wholly luck," Mr. Binger concluded, "but having a lot of luck of this kind takes not only a research approach but the accompanying willingness to undertake research in many directions, and to follow the results of research wherever they may lead."

Selecting Research Objectives

Clifford F. Rassweiler, Vice-Chairman of the Board and Vice President for Research and Development of Johns-Manville Corporation, stressed that "to be planned, experimental activity must have an *objective*. The plan for reaching the objective may change as the work progresses, but the effort must never be aimless or hap-

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FACE TO FACE

R/E interviews E. DUER REEVES, Exec. V.P.
Esso Research & Engineering Co.
on Researching Research
The Real Engineering Shortage
Present Planning for Future Research

Mr. Reeves, how does the Research & Engineering laboratory fit into the general organization of the Esso companies?

Standard Oil of New Jersey is essentially a holding company; it has subsidiaries and affiliates throughout the world that carry out various types of operations—oil producing, refining, marketing, and so on. Esso Research & Engineering is one of these subsidiary companies. We were set up to provide the Esso family with the technology it needs; but once having been established, our relations with other members of the family are directly with the affiliates.

Then you are in the position of an independent company dealing with customers?

Yes. The only difference is that our customers are for the most part Jersey affiliates. These affiliates don't have to use our services if they don't wish to; so, in effect, we are in competition with anybody who can supply technology to a Jersey company. This gives us a great incentive to be sure that we have satisfied customers. Toward that end, we spend a great deal of time and effort to make sure that we offer them the best in technology and services. We want them to feel that coming to us for these things is much more effective than going somewhere else.

It seems that you might almost have a budget for intra-family advertising.

We don't quite go that far. But our public relations department spends a good deal of time working with the affiliates.

How about the structure of the lab itself? How is it organized?

Just as the Jersey companies are decentralized, so are the labs decentralized. Within the structure of Esso Research & Engineering are ten technical divisions—these are the basic operating units of the company. They do most of the research, development, and engineering work for Esso Research. In addition, various of our operating affiliates—Imperial in Canada, Esso Standard in this country and others—maintain their own research divisions: we contract with them for some research and pay them for it. In doing that we always try to be sure that the work they do is coordinated with the work of our own divisions. In this way the total effort to acquire technology is done not only within Esso Research & Engineering's own corporate organization, but extends as well to the labs of affiliated companies.

What's your job in all this activity?

My job as part of top management at Esso Research is to try to look

(Continued on page 20)

Interview and Photographs by Lawrence Sandek

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FACE TO FACE *(Cont. from p. 18)*

ahead, to try to see what needs to be done, and to try to be sure that the organization is available to do it. I also work on the coordination of the activities of the various divisions both within the company and outside it, and the translation of technology into effeecitve operations in the operating units throughout the world.

Then much of your job consists in what might be called informed speculation.

That's right. We spend a great deal of time trying to make that speculation informed. I can give you a good example of that in motor fuels. Transportation is not something that people in this country buy just for its own sake. A car is a luxury. That fact has quite an impact on the type of performance that people expect of a car. So the first step in this informed speculation is to settle in our mind what the ultimate consumers are going to want over the years. Having decided that, we then have to try to evaluate the ability of the automobile manufacturerers to meet that consumer demand in their field: will they use spark-ignition engines, free pistons, gas turbines, or what have you?

Once having settled on the possibilities, we then have to translate them into the types of energy products that are going to be needed. This analysis of possible future requirements gets pretty detailed; it involves, for instance, determining the specific composition of the fuel that's going to be needed and the processes we are going to have to develop to produce it.

Finally, by considering all these factors, we can—we think—develop a pretty good notion of just what is going to be required of the oil industry, and we can start planning accordingly.

It appears then that research is not something that follows a simple direction. You probably have contributing to one major product several paths of development, each following independent directions, but all tending toward a common goal.

That's right. You sometimes have to put yourself in a position from which you will be able to jump in two directions. A good example of that is the current debate about the spark engine. A lot of people feel that gas turbines will come in for automobiles, or that possibly nuclear energy will, or perhaps free pistons. Now when you evaluate these ideas you don't wind up with something that's black or white. What you have is an evaluation of the possibility of going in different directions. Even though the odds are 95-to-5 for a particular direction, there is still the possibility that it won't come through that way. So if you're on your toes, you'll still keep that small possibility in mind. You've got to remain flexible by hedging your bets.

What do you mean by "hedging"?

What I mean is this. We would say that the chances are remote of having very many automobiles powered by gas turbine engines in the next 10 years. But that doesn't mean it's impossible. What we have to think of, then, is the position we would be in if that remote chance did take place. We've got to be prepared to revise all our operations to provide the type of fuel that will be needed in the event that that possibility occurs. This means that in designing plants to make high octane spark ignition gasoline, you've got to think about whether those plants could be converted to make another type of product. This might be an important factor in choosing the plant and process you finally decide on.

In addition to these speculative matters and the broader administrative functions of your job, are you involved in administering research teams?

Yes; I am a member of the Executive Committee which has the responsibility of overseeing the general well-being of the company. We have to satisfy ourselves that we have a good forecast of what we need to do; that we have an effective organization to carry out the work; that our people are being trained properly; and, after the work is done, that it is properly digested, and translated, and presented to the affiliates; and, finally, that each affiliate is given all the help it needs to use the technology.

The point I have specifically in mind is the matter of research team productivity. Does that come within your purview?

Yes it does. We are doing a lot of work on what you might call research on research—trying to find out how you might do research work more effectively, how to create the kind of environment that will stimulate a creative person to be more creative. The Executive Committee is responsible for recognizing the problem, for getting a group organized to do something about it, and then satisfying itself that something is being done about it. But again, we do not do the actual work; the execution of the program is left to the Work Simplification Committee, which is largely composed of the Division directors under the leadership of a vice-president.

Would you say a bit more about this "research on research"?

Yes. Let me start with the supporting services since about 2/3 of our people are involved in this work. This includes people who do mechanical and analytical work, who operate our pilot plants, who do clerical and stenographic work. The working methods of these groups have been improved by work simplification programs in which everyone participates. After some extensive job analysis, better ways were found for selecting a person for his job, better ways of organizing the job itself, and in some cases, it was found that the job wasn't necessary in the first place. The result has been a substantial improvement in the efficiency of these service groups. Part of the reason for that improved efficiency too, is that many people have wound up with better jobs than they had before.

Now, research on research is no more than applying these same principles to research and engineering. There are a great many ways of improving efficiency in those operations. In engineering for example, it is possible, by using the new electronic calculating machines, to improve the effectiveness of an engineer as much as 4- or 5-fold.

The new machines are expensive, but their expense is offset by the fact that they free the really creative engineer for more creative work—and that's one way of easing the engineering shortage. The machines make pos-

(Continued on page 22)

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sible a better planning of experimental work and a more accurate analysis of experimental results. In this way research itself becomes a more productive thing.

There's another side to this—the future of technology. Technology is growing in this country at the rate of about 12 percent a year. But technologists are not being turned out at anywhere near that rate. This means that if technology is to continue growing, we've got to make better use of the people available to us. So the problem is not so much turning out 12 percent more *people* every year as it is increasing our technical output 12 percent each year.

And you think that the electronic calculators are helping us do that?

Yes. But not only the calculators, better techniques are contributing too. We can do things in industry so much better today than we could 15 years ago. The machines and processes require a higher capital investment for an operator in a plant, but that operator is doing things alone that formerly required a great many operators. One man is now equal to several.

These are the reasons why, despite the present tight supply of engineers and scientists, I'm optimistic about our technological future. So much so, that I believe that the only factor that is really going to regulate the pace of technology is the ability of industry to absorb and use it. I think that as time goes on, we can produce all of the technology that is going to be needed, and I don't think that in the long run the shortage of technical people is going to have any effect on us at all.

Then by-and-large you feel that the engineering shortage is not acute.

Well, one thing I'd like to make clear on that subject is that we will always have an engineering shortage. These machines can't think and will never replace the creative engineer. One of the things the machines can do, however, is replace those engineers who are primarily technicians, of whom, in my opinion, there will not be a shortage. But in replacing these men with machines, we are creating an even greater demand for the truly creative engineer or scientist. It is in these that we will always be in short supply—we are now, we always have been. But this is true not only in science but everywhere else—we can never have enough of creative people.

Do you, in your continual efforts to streamline your operation, use psychological testing?

To some extent we do. We are supporting a lot of work along that line but we do not feel that it has come to the point yet where it can be of positive benefit.

There's a good deal of talk about psychological testing; I'm not sure that it's not done mostly by the testers, but there are some indications that industry is depending increasingly on pretesting because the investment in a man is so large.

Yes the investments are terrific. One of the psychologists we are supporting now is trying to find out what the differences are between two groups that he has designated *creative* and *non-creative*. Apparently environment is an important factor in the difference. Well, that's all extremely difficult and we think it will be some time—if ever—before he gets specific answers.

Then you look upon the whole enterprise as a research possibility—something that might or might not pay-off in the future.

That's right, we think of it as an attempt to get some basic information in an important field. We're supporting its development in the hope that if it is developed, it will turn out to be very useful, but you can't tell right now.

One final theme, Sir. There is considerable controversy about the problem of getting more basic research. I wonder if you're concerned with that problem in any way?

I've given it a lot of thought and I think you might say I am concerned, but not disturbed.

Why not?

Because I think there's a lot more basic research being carried on than is commonly realized. A lot of the trouble is in the definitions. Many people define basic research as research without some particular thing in mind. Now, almost all industrial research is done with a purpose. We will study the thermodynamic properties of hydrocarbons, for example, because we want to develop an isomerization process. But since we have a *goal* in view, then by this definition we are not doing basic research. On the other hand, were a university to carry out the same program, it would be called basic research.

But isn't there something to be gained by a scientist just following his curiosity without any possibilty of present application for his findings?

Well, I don't think that's any better than trying to think of where he's going. Both academic and industrial researchers are strongly motivated. The academic researcher is motivated toward solving a problem that he's interested in personally. The industrial researcher is motivated toward solving problems that are of interest to other people. Now it doesn't seem to me that either motivation, so long as it is strong, has any further bearing on how good the work is. The important thing is whether or not the frontiers of knowledge are being pushed back.

I'm proposing a situation in which, for some applied development, we need some knowledge—some pieces of information. We find it somewhere on a shelf—it has been discovered but has never been used; now we pull it down and use it. Were it not found on the shelf, wouldn't its absence cause the expenditure of appreciable time and effort in the attempt to discover it?

Well I don't deny that it's nice to have things sitting on a shelf well ahead of time. On the other hand, the more important thing is to have it when you need it—it doesn't have to be there 10 years before you need it.

This is precisely what industrial research tries to do—it tries to plan ahead and define the areas in which it is going to need fundamental information and it tries to be sure that the information will be there when it's needed. Which means that it has to sponsor fundamental research so that the schedule can be met.

There are really three things that are critical. One is to know what's needed. Another is to create the technology that's needed. The last is to

(Continued on page 46)

psychological testing

Mortimer R. Feinberg, Ph.D.

THE EARLIEST RECORDED DISCUSSION of manpower selection is in the Old Testament's Book of Judges. God called on Gideon to raise an army to smite the Midianites. Gideon recruited 32,000 men but God said that the army was too large. So Gideon devised several tests by which he eliminated those who lacked stamina and those who lacked courage. His final test, on alertness, was to lead his army past the bank of a river. All those who carelessly threw down their shields and spears and lapped up the water with their backs to a possible enemy were eliminated. Gideon selected only three hundred men. With this small force he smashed an army three times as great.

There is a long gap between Biblical days and the present. The revival of selection techniques on a mass basis started in our time with the First World War. In that conflict, these instruments were applied to help measure the intelligence and personality of recruits. After the war, however, industry found that these tools were not adequate to meet its requirements. The instruments themselves were not perfected, management was uneducated in the potential of testing, and there were not enough psychologists to properly administer the tests. It was not until World War II that psychologists came into their own with mass classification of pilots, navigators, tankmen, infantrymen and engineers.

Following the war, industry again turned to testing. Management recognized that if tests could help in the selection of officers, they could also assist in the selection of executives and engineers. Psychologists made a concerted effort to help industry in the important job of picking the right man for the right spot at the right time. Today testing is widely accepted and used.

How does psychological testing work?

Let's take a look at a test and define what it is, what it can do and what it can't do. Basically, a psychological test is a sample of behavior, an attempt to do a selecting job better than can be done by guesswork. Though better than subjective judgment and interviews, a test doesn't replace these techniques; it merely supplements them. It is a tool to increase one's batting average, to eliminate some error and save time in the selection process. However, a test must never be used alone. It was designed to be used in conjunction with other techniques.

Breakdown of the Job

The first step in the development of any selection program is a job analysis. This is merely a breaking down of the job in question to determine what activities are being carried on—what psychological functions are required for success on that particular activity.

Before we can hope to develop tests for the selection of any occupational group, we need to know as much as possible about what the individual actually does to perform successfully. This knowledge must be complete, precise, specific, and adjusted to the requirements in each company.

The Yardstick

The second step in any selection program is the development of criteria based on the performance of high and low groups. This is done by examining and comparing those employees who are successful against those who are not performing successfully. The criterion of successful performance can take many forms. It may be a simple rating of job effectiveness by supervisors,

Establishing Criteria

What activities can provide measurable criteria? Merit ratings, indicators of creativity (patents, new ideas), productivity measures are customary standards. Often these may be difficult to obtain. Supervisory rating may be decided on as the final arbiter. The psychologist, in consultation with mangement, decides upon the psychological aspects most desirable for future selection. In one study for the selection of engineers, the Carrier Corporation obtained ratings on (a) ability to get along well with others, (b) creativity, (c) effort and conscientiousness, (d) job knowledge, (e) motivation and drive, (f) over-all effectiveness. The high and low groups were established on the basis of these criterion ratings.*

In another study conducted by Richardson Bellows and Henry Co., a consulting organization, the raters were asked to evaluate their subordinates on the basis of supervisory potential. Each supervisor was given specific instructions by the psychologist. In all cases the psychologist's guidance in the collection of these ratings is the most important step.

Selection of Tests

The following tests might be included in the initial trial battery:

- Productive Thinking—Measuring extent of an individual's productive thinking potential.
- Engineering Aptitude—Mathematical formulation, spatial visualization, etc.
- Personality Inventories—Measuring personal and emotional adjustment.
- Supervisory Ability—Ability to coordinate, direct, and guide the work of subordinates.

Testing the Test

This requires administering the total battery to a sample of engineers who have been ranked. Correlate the test scores with the criterion. If the tests are doing their job, the top group on the criterion should receive high scores on the test battery. In one fairly successful study, 95% of those rated medium to high in job performance received high scores on the test and only 5% scored low. Conversely, 85% of those rated low in job performance received low test scores and only 15% scored high.

*Kirkpatrick—Personal Psychology, Vol. 9, 112, '56.

or it can be more detailed: production records, absenteeism, job history or creativity—possibly a combination of all of these. But essentially at this point the basic problem is to differentiate the high from the low group, the successful from the unsuccessful. We are now, in effect, developing a slide-rule against which to validate the test. All practical results are still in the future.

(Continued on page 36)

Reliability—
THE FACTORS OF FAILURE

Richard R. Landers

THERE IS A GROWING CONCERN in industry over the increasing number of failures that accompany the launching of complex electronic equipment.

What has caused this wave of unreliability? The main reason is that technology has mushroomed far beyond the limits of present reliability knowledge. Undoubtedly, we will eventually develop failure-free, long-lived components, able to withstand the more extreme environments. To keep these equipments going, however, will take techniques that have yet to be developed.

This article does not presume to describe a method that will insure continuous and satisfactory performance of intricate systems, but rather suggests an approach to understanding the problem. Reliable prediction will come as a reward of this understanding.

Understanding Reliability

As every experienced teacher knows, the first prerequisite to understanding is the clearing away of misunderstanding; and this applies to reliability. Almost everyone associated with complex equipment feels that he has a full understanding of reliability. More often than not, however, his understanding consists of little more than antithetical generalities. For example, one theory has it that we can increase reliability by reducing the number of parts. Another calls for doubling the number of parts. One maintains that the best preventive maintenance is no maintenance at all. Another claims that constant attention will keep any machine going forever. These conclusions are based on the individual's experience. If subsequent experience proves his theory wrong he can conveniently switch to the opposite theory. Thus it is always possible to generalize reliability theories into two sets of principles that can be applied regardless of the nature of the problem.

The reliability expert also tends to idealize the problem. His emphasis is usually on how an equipment *should* perform and hardly ever on how it *does* perform. In other words, intentions are substituted for reality.

To understand reliability we must be able to describe, predict, and control the behavior of equipment. With this understanding we can express an equipment's reliability characteristics, determine what these characteristics imply, and in some degree control their occurrence.

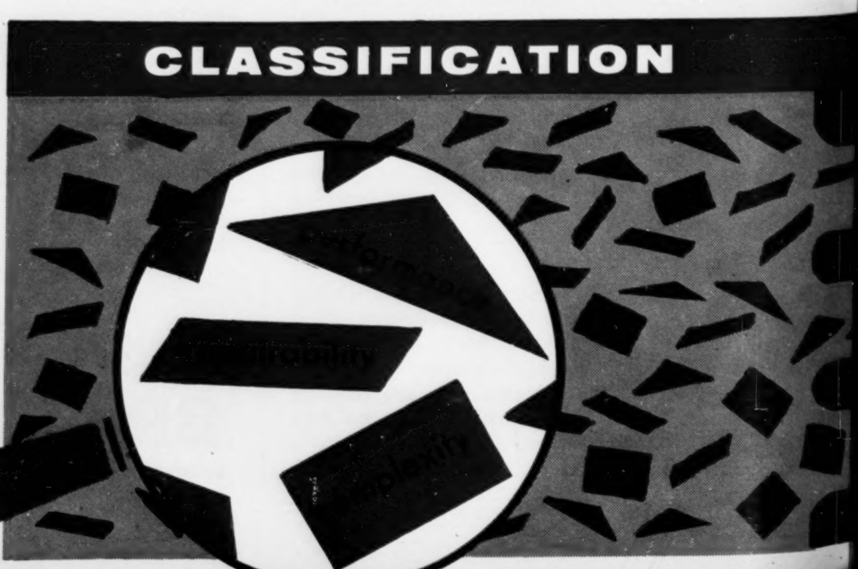
If we understand the characteristics which lead to equipment failures, we can possibly anticipate and prevent or correct failures before they happen. Or we can delay their occurrence to a more convenient time.

Major Factors Effecting Reliability

Where must you focus attention in order to understand the factors which effect reliability? There are three major areas of effort:

1) determining reliability factors,
2) analyzing these factors, and
3) controlling them.

Reliability Factors



This is The Second of Two Articles Examining the Premises of Reliability

Determining Reliability Factors

Summing up individual equipment characteristics under the one category of *reliability* is useless because, if we are to determine equipment behavior, we must first isolate and examine the characteristics separately.

What are some of these equipment characteristics? They are traits that cannot be measured directly but are usually described in pairs of opposites, such as complexity-simplicity, stability-instability, accuracy-inaccuracy, etc.

Capabilities differ from characteristics in that they can be measured directly. Such things as repairability, mean life-to-failure, serviceability, etc., are definite usually vary from a zero quantities varying from zero to some maximum value.

Also, we have *determinants of reliability capabilities*, that is, such as design, environment, operation, maintenance, etc.

Finally, we can join these characteristics and capabilities into various *reliability group factors*. These groups have effects which are more or less independent of each other. Examples of group factors are life, performance, maintenance, cost, etc.

Factor Interactions

After we have isolated these characteristics and capabilities and evaluated them separately, we still must determine their influence on each other and on the equipment as a whole. We can divide these effects, in turn, into primary relationships: characteristic vs group factor (such as the effect of maintenance on life and on secondary interrelationships), characteristic vs characteristic (such as the effect of equipment deterioration on maintenance).

Here are some basic steps which may be used as guides for those interested in modifying and regulating equipment performance:

1. Define the meaning and objectives of reliability control.
2. Determine the parameters to be controlled and their relative importance.
3. Prescribe the method of identifying and measuring these parameters.
4. State the primary relationship of these parameters to reliability and the interrelationship of one parameter with another.
5. Consider the method of improving or changing each parameter.
6. Describe methods to monitor and determine degrees of control effectiveness.

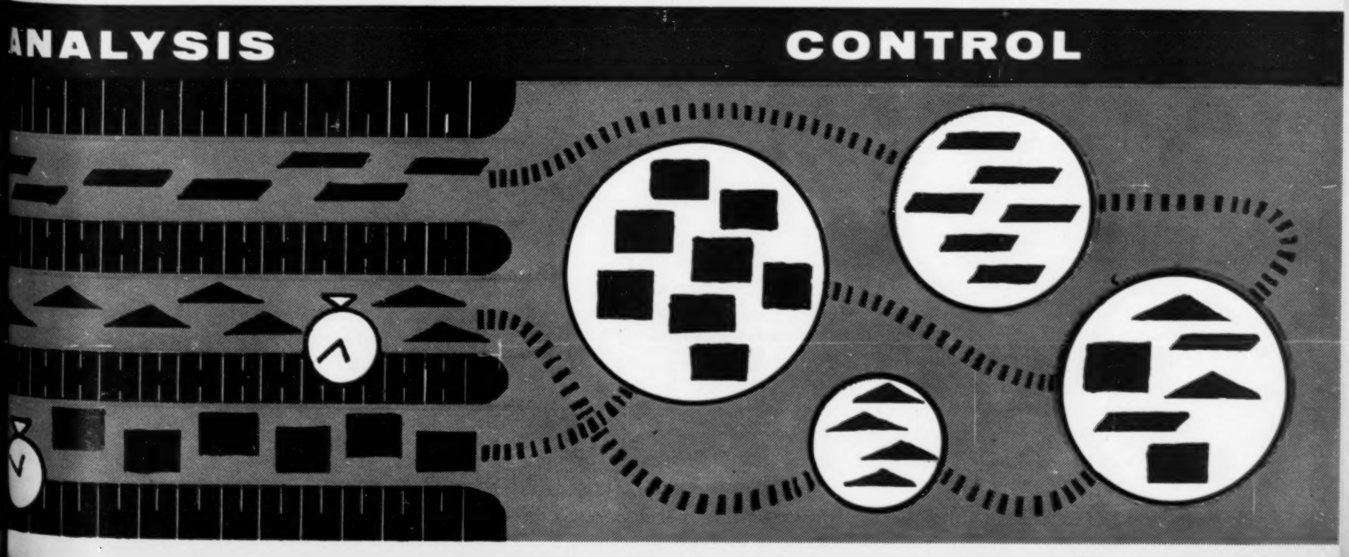
Areas of Unreliability

As I mentioned previously, it is easier to recognize and measure those things that go wrong than those that go right. Here we speak of unreliability as opposed to reliability.

Unreliability divides into three groups: 1) deficiencies of the equipment itself (design deficiencies, component defects, and manufacturing errors); 2) the controllable wear the equipment receives in use (operational and maintenance errors); and 3) the uncontrollable wear which the equipment receives (being hit by a truck, etc.)

(Continued on page 30)

The factors with which reliability prediction is concerned and the method of dealing with them are here depicted. Such considerations as performance, repairability and complexity, are classified and analyzed. From this ordering activity arises control, as an almost inevitable consequence.



ARMOUR'S

Research Conference

(Cont. from p. 17)

hazard. For one reason, a good research organization is made up of aggressive, imaginative people who resent dictation and overseeing. The way to direct without dominating is to give each man a clear objective which will represent a worthwhile accomplishment, and give him the greatest possible freedom in reaching that objective.

Worthwhile Goals

"Part of planning and defining objectives is seeing that the objectives you select are worthwhile ones," Mr. Rassweiler explained. "Everybody wants to feel that he is working on something important. Explaining why the objectives are worthwhile is one of the greatest aids to laboratory morale. Nothing destroys morale more than letting men struggle to produce something which will be discarded."

Why do R/D managers so often fail to make their objectives clear? Mr. Rassweiler suggests three reasons. One is the failure to recognize the real customer. In one case a company spent large sums on development and actually built a plant to produce a product for a large corporation. The corporation's purchasing vice president assured them that his company would consume the product in large volume. The manufacturer, however, discovered too late that it was the chief engineer, not the purchasing vice president, who had the final say as to what product would be consumed, and he could not be persuaded to buy any of the manufacturer's output.

Why Customers Buy

Second, an R/D manager may fail to learn what considerations will determine the buyer's decision to buy. Said Mr. Rassweiler, "In dealing with an industrial consumer, this is often a very complicated matter. It involves an understanding of the specific test methods which will be used in the customer's evaluation, and even a knowledge of the personal prejudices of some of the key people in the test organization. In finding what influences the ultimate consumer, the problem is even more difficult.

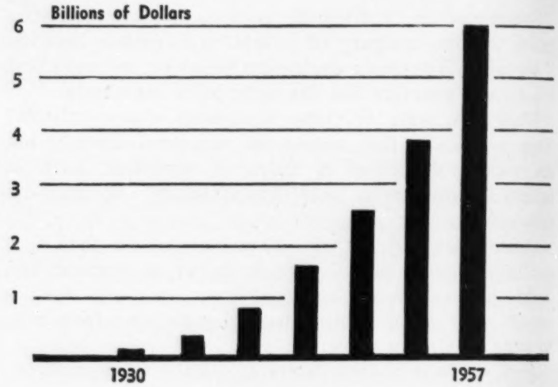
Finally, the customer's own idea of his needs should be critically examined. Too often the research department takes the customer's analysis at its face value. In one example, a customer was having trouble with damage to the finish of his metal cabinets during shipment. He decided he needed a harder finish. Analysis of his real needs showed that the damage was actually caused by the flaking of a brittle finish when the thin metal sheets of his cabinets were flexed during rough handling. The customer needed not a harder finish, but a more flexible one.

In Terms of Function

Mr. Rassweiler summed up his theme by saying, "It is only after the objective has been defined in accurate terms that the research director can intelligently set a technical objective for his laboratory's experimental research. Even the technical objective must be in terms of what the product is to *do*. The research organization itself should be left with the greatest latitude in deciding what a product should *be* in order to have the utility and customary action which have been analyzed as necessary for commercial success."

RESEARCH IS A BUSINESS

Industrial research has grown from a 3 to 4 million dollar activity in 1930 to a 6 billion dollar industry today. It is a business—one of the nation's most vigorous.



Mr. E. Duer Reeves, Executive Vice President of Esso Research and Engineering Company put this question to the meeting: "If industrial research is a business and has a definite job to do, then what is that job and how does it go about doing it?" He proposed that research and development has four primary responsibilities:

1. Knowing what technology its company needs
2. Creating the needed technology
3. Helping the company use technology effectively
4. Operating efficiently
5. Being an effective member of the management team

A Crash Program?

Mr. Reeves stressed the importance of timing in laying out a research program. Which problems are long range? Which ones are short range? Which ones demand a crash program? Said Mr. Reeves, "This type of analysis is necessary to insure that there will be a steady flow of technical solutions from year to year. If the research organization concentrates on crash programs it certainly will not be building a background for the future. On the other hand, you cannot afford to disregard crash programs entirely. If you do so, it is quite possible the company will be out of existence when the long-range research is completed."

Balanced Portfolio

"Some research objectives are rather insignificant, and the risk of failure is correspondingly negligible. These are what we call the blue-chip problems. They form the backbone of the research program. There are other problems which are very significant, but are also very risky. Work on these problems requires enormous outlay of funds on an unpredictable basis. The R/D management should strike up a balance between these various investments corresponding to what might be termed a balanced portfolio in investments."

Another difficult decision, Mr. Reeves said, is deciding what the total R/D effort should be. "You cannot turn research programs on and off as you can a water spigot," he pointed out. "In any company, today's research

effort is largely the result of plans laid several years in the past. By the same token, in setting up its future plans the company must look well ahead and decide what it is going to be doing three or five years from now. This involves a whole series of calculated risks. Yet the company must determine what it needed in the way of technology if its research programs are to bear any relationship to its needs for research results."

MAKING WASTE PRODUCTS PAY

One of research and development's unsung yet highly important contributions to life is the disposal of waste products. V. Conquest, Vice President, Research Division of Armour & Company, described to the Armour audiences some of the most notable accomplishments in the handling of waste products.

Agricultural wastes are the oldest waste products with which man has had to deal. While there are still a few real waste products from agriculture or agricultural processing, most have moved into the category of by-products. Cellulosic wastes are used in animal feeds. Sugar cane waste has risen all the way to a main product status —Celotex.

"The chemical utilization of cellulous wastes is another interesting story," Mr. Conquest said. "Some of us can remember when furfural was a scarce and expensive chemical. At the time Quaker Oats Company started research on the production of furfural, there probably was a known market for it of a few thousand pounds a year. Determined to find other uses for their cellulosic wastes, through the furfural route, Quaker set up the proper research and development organization.

Bubbly Creek's Loss

"In its early days the meatpacking industry really had a waste product problem. Stories are told of the Chicago practices of hauling bones and other wastes to the then vacant prairies for burial; of the disposal of liquid waste—blood and fats—by pouring into the south end of 'Bubbly Creek'.

"We don't know who made the first move to keep these wastes in the factory and make soap from fats and fertilizer from these bones and proteins. This was the step that changed these fats into by-products. Later it was discovered that the protein and bone residue had valuable use in animal and poultry feeds. With some exceptions, such as raw material of gelatin and glue, hides for leather, and blood adhesives, the main outlets for protein residues of the meat industry is still animal feed."

Hydrogen into Ammonia

A waste product problem confronted the petroleum industry in its early days, Mr. Conquest reported. Some petroleum refiners have what they can term temporarily a surplus of hydrogen, now turned into ammonia. There are still some waste gases in the petroleum fields, but this waste problem will be solved in time.

"The main point," concluded the vice president of Armour Research, a pioneer in the waste disposal area, "is to organize properly on the problem and then give it a double dose of patience and effort. You will surely be rewarded handsomely. And you will not have the disagreeable tag of waste product in your operations."

Reliability—

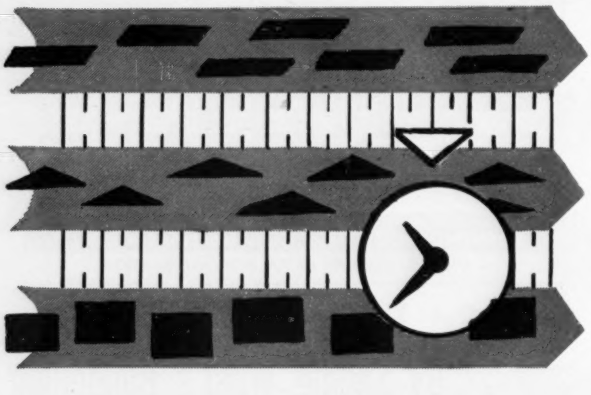
(Continued from page 27)

With this formulation of an organized and systematic method to isolate and classify the elements of reliability, we are ready to examine these elements.

Reliability Analysis

Finding departures from optimum performance is the role of reliability analysis. This requires that we describe how internal and external factors affect equipment performance.

Performance is the extent to which an equipment meets the specifications to which it is built. Adequate performance means that the minimum limits are being met. Optimum performance means that the equipment is functioning satisfactorily with some margin of reserve to compensate for normal deterioration.



In practice, it is as difficult to determine the degree of satisfactory performance as it is to determine how healthy a person is. The only practical way is to observe the *length of time* that the equipment remains in the optimum state of performance. In this sense, optimum performance is simply the absence of trouble. An analogy might be helpful here. A physician can help you avoid stomach troubles (preventive medicine). The thing a physician can't do is to make a stomach (creative medicine). The parallel is that we have *preventive reliability* where we attempt to keep the designer from making a mistake, and *corrective maintenance* where we try to repair an error once made. If there is any *creative* reliability it is in the designer's domain. Being aware of this, the reliability engineer realizes he can contribute most by supplementing the work of the designer and not by competing with him. Reliability must generate its own techniques and methods, and not merely take over functions that existed before reliability became a distinct discipline. How can we do this?

We start where the designer leaves off. We set an objective for reliability. That objective is continuing, stable, consistent, and trouble-free functioning of an equipment which has already proved capable of meeting its specified performance at least once. It is only here that the reliability engineer can start a realistic analysis of the equipment.

Gestalten

The reliability engineer's approach to a complex system differs from the design engineer's. The design engineer sees the equipment in the way that he created it—that is, from the individual components, the circuits, sub-assemblies, assemblies, and finally the complete system. As a result, he finds himself too close to the equipment. If the reliability engineer is to avoid this myopia he must see the equipment as a system first, and then as assemblies, and finally as components.

Anyone who has ever asked a television design engineer to diagnose a symptom of a faulty TV set is aware of this reverse perspective. The designer reviews all the circults and calls to mind a hundred possible causes for the particular sympton. He would have you not only replace component parts but also change some of their values into the bargain. A TV serviceman, on the other hand, approaches the set from the external controls first and then proceeds inward. He has learned from experience that there are more service calls because the station selector is on the wrong channel (in one station towns) than there are because of an overly sensitive sync circuit.

Bad data cannot be made good by statistical manipulation. Good data may be invalidated by unsound statistical methods.

Repairability

It is essential to reliability analysis that we clearly define the methods and units of each reliability factor. We can then proceed to chart the effects of time on these factors. Let us consider one of these factors—repairability—and see what is involved in performing a reliability analysis.

Repairability is the degree to which an equipment lends itself to the discovery, repair, and checkout of malfunctions. It can be measured as the average length of time needed to detect, correct, and re-test each malfunction. It is expressed as *hours per failure*. If we strive for an equipment with an extremely low repairability value, we increase the probability of failure and defeat our purpose. For example: We can organize an assortment of elements into a plug-in component, but the plug-in needs a socket: Thus, a new source of possible failure is introduced—the socket. The optimum repairability must hinge on other related characteristics, such as *maintainability** which is the inverse of repairability. Making an equipment easy to maintain may also make it more difficult to repair. For example: an automatic transmission or sealed refrigerator unit. In these cases you can achieve optimum repairability by removing the complete assembly and replacing it with another.

In any event, we cannot be satisfied with merely knowing the average value of repair and maintenance times of equipments. We must also determine their time distribution forms and variations. Knowledge of these is essential to control repairability and maintainability.

Reliability Control

The purpose of Reliability Measurement and Analysis is Reliability Control. This controls most of those parameters governing equipment behavior. This control is exercised during design, manufacture, operation, and maintenance phases.

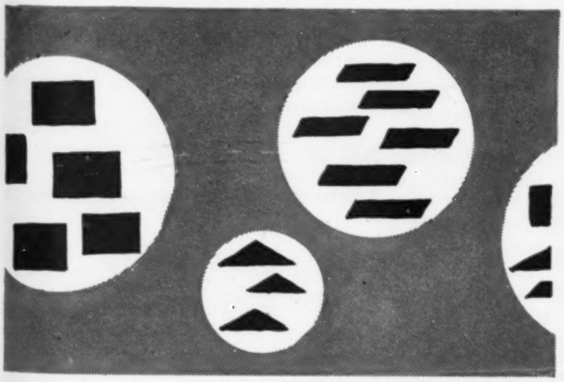
*Maintainability of an equipment is the amount of effort necessary to keep it operating efficiently. It is measured as the percentage of time spent on maintenance for resultant time of trouble-free operation.

Efficient performance can take many forms: it may be long life (as in submarine cables); it may be short life with full assurance of operation (as in guided missiles); or it may take the form of non-replacement until some predetermined time as was the case in the "wonderful one hoss shay" that lasted a hundred years to the day. In any event performance objectives must be clearly stated.

Reliability control, and hence product improvement, depends upon detailed knowledge of reliability factors. With that knowledge we can, for example, measure an equipment's rate of deterioration, and thereby maintain its initial ability. Or if its operation is needlessly complex, we can determine where best to simplify it.

We must bear in mind that control means *to keep within limits* and not *to keep improving*. In improving reliability, engineers often use the weakest-link-in-the-chain technique. That is, they subject an equipment to a test, and if a part fails or breaks they strengthen it. Such testing of a unit may disclose some weak components, but it will not improve the reliability of the system as a whole, since strengthening one component may result in weakening another.

Consider a table that is unstable because of uneven leg lengths. To achieve stability we must measure each leg and compare the lengths with the desired height. We may have to shorten some legs and lengthen others. If we were to employ the weak-link philosophy and keep adding to the shortest leg we would wind up with a table indefinitely high.



Just as adjusting leg lengths requires a standard of table height, so strengthening weak links requires some standards for reliability. Without such standards, reliability control is impossible. We can evaluate the effectiveness of reliability control by measuring "the probability of the device performing its purpose adequately for the period of time intended under the operating conditions encountered", and comparing the result of this measurement to predetermined specified values.

Summing Up

Every reliability program should contain at least the following three elements: 1) determination of reliability factors, 2) reliability analysis and 3) reliability control. With such a program, reliability measurement will take on a realistic and effective meaning, and in that way make a significant contribution to engineering.

LABORATORY EQUIPMENT

Amplifier

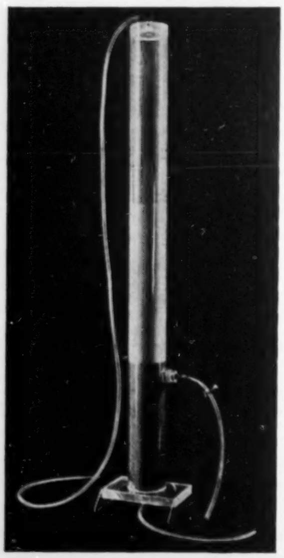
A new amplifier for laboratory use is designed for applications where high input impedence and broad band response are required. It is useful for maintaining low frequency response and signal level of piezoelectric accelerometers, pressure pickups and similar transducers. It works well into measurement equipment where load impedence is greater than 5000 ohms. Atlantic Research Corp., 901 N. Columbus St., Alexandria, Va.

CIRCLE 30 ON PAGE 48 FOR MORE INFORMATION

Nitrogen Generator

A newly developed nitrogen generator has a wide controlled-hydrogen-content range. The Nitroneal generator produces oxygen-free nitrogen much more economically than previous devices, and is said to be much safer than conventional ammonia dissociators. It draws nitrogen from both air and ammonia, rather than from the ammonia alone. No external heat is necessary, since the reaction is exothermic, and its platinum catalyst has an indefinite life. The unit is fully automatic, requiring no maintenance, and can be operated by an unskilled worker. Baker & Co., Inc., Instrument Div., 207 Grant Ave., East Newark, N.J.

CIRCLE 31 ON PAGE 48 FOR MORE INFORMATION



Microwave Stability Tester

Changes in the frequency of microwave oscillators can be measured to a new high degree of precision with a new microwave stability tester. At S-band the change that can be indicated is less than 2 cps. The instrument measures drift and rate of drift, and has many applications where the determination of stability is important. The Model 5004 Tester is adaptable to take readings at S-, L-, C- or X-band. Stability measurements can be taken at 30 mc and from 30 kc to 230 kc. Reading can be taken instantaneously and monitored continuously. Laboratory For Electronics, Inc., 75 Pitts St., Boston 14, Mass.

CIRCLE 32 ON PAGE 48 FOR MORE INFORMATION

Electro-Mechanical System

This non-electronic signal generator system measures, indicates, transmits and controls a variety of process variables: pressure, differential pressure, flow, liquid level, temperature. High reliability, low maintenance and extreme flexibility distinguish the ElectroSyn. The system can be installed and then enlarged upon to meet facility expansion. True null balance assures the system's accuracy, and electromagnetic transducers and magnetic amplifiers provide unlimited life. Three basic components compose the system—a signal transmitter (transducer), a power unit (magnetic servo amplifier) and a null-balance indicating receiver. Norwood Controls, Unit of Detroit Controls Corp., Norwood, Mass.

CIRCLE 33 ON PAGE 48 FOR MORE INFORMATION

Demineralizer

Purification by ion-exchange to produce lab water of over 1 million ohms per C.C. having an almost constant 7pH level, is possible with a new mixed-bed regenerative demineralizer. Cation and anion resins are mixed in one resin bed, so that the ion exchange process can take place hundreds of times as the water flows through. The Model MM-O removes approximately 1100 grains per regeneration. Flow rate is from 10 to 30 gallons per hour. Barnstead Still & Demineralizer Co., Boston, 31, Mass.

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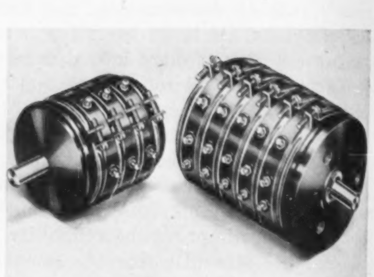


Precision Potentiometer

This precision potentiometer provides unlimited phasing. Outstanding features are extreme compactness and high temperature compatibility. It includes ⅝" depth per section, continuous service up to 150°C; stainless steel clamps with unlimited phasing range; large number of taps, limited only by physical spacing; reliable performance under high "G" or vibration conditions; three styles of mounting: servo, bushing and 3-hole bushing; available in ball or sleeve bearings, shafts as specified. It comes in three sizes: RL-270B-1⅝; RL-270B-2; and RL-270B-3. The Gamewell Co., Newton Upper Falls 64, Mass.

CIRCLE 35 ON PAGE 48 FOR MORE INFORMATION

Three New Devices

Three new instruments have been introduced for checking, testing and measuring applications. The first of these is a spectral power density analyzer (Model PDA-1) which automatically analyzes the energy distribution of random information, and can be used for evaluating noise, vibration and other changing phenomena. The second is a synchronous frequency analyzer (Model SF-1). This automatically tracks a frequency component derived from a rotating or oscillating source and simultaneously provides a visual plot of component frequency vs. component amplitude. The third device is a 7-point frequency calibrator (Model TMC-307). It sequentially furnishes seven equally spaced frequencies per channel for all RDB channels within end limits of ±7.5%, within end limits of ±15% for the upper five channels. Panoramic Radio Products, Inc., 10 S. 2nd Ave., Mount Vernon, N.Y.

CIRCLE 36 ON PAGE 48 FOR MORE INFORMATION

Testing Machine

An automatic testing machine has been developed for maintaining a fixed extension or strain when testing at elevated temperatures. The tester operates on a principle directly opposite to that of the familiar creep tester. A circular electric furnace mounted between the crossheads can be used for testing at any temperature up to 1800—2000°F. Temperatures are controlled by a separate unit. Tinius Olsen Testing Machine Co., 5397 Easton Rd., Willow Grove, Pa.

CIRCLE 37 ON PAGE 48 FOR MORE INFORMATION

Handy Mixer

A quick, accurate method has been devised for mixing pH buffer solutions. A pre-measured envelope of powder is simply emptied into and shaken up in a polyethylene bottle holding the proper amount of distilled water. A kit is available, consisting of three dispenser-top, 500ml bottles labelled for pH 4, pH 7 and pH 9, together with vapor-proof envelopes of powder to make three each of the three values. It sells for $6.00. Analytical Measurements, Chatham, N.J.

CIRCLE 38 ON PAGE 48 FOR MORE INFORMATION

Massive Plastic Fluors

Solid solution plastic fluors for use in scintillation counters are offered commercially in hitherto unavailable size ranges and shapes. These are: rod forms in diameters from 3" to 18", in lengths up to 36" in 24" x 24" sheets, in thickness up to 8". The material may also be ordered cast to predetermined shapes and close tolerances in a wide range of sizes. Light output efficiency of the styrene fluor is 0.36. The wave lengths of its fluorescent emissions is 4,200-4,600 Angstroms. Decay time, measured by pulsed X-ray excitations, is 4×10^{-9} seconds. Self-absorption of fluorescence is low, reflecting the effect of the tetraphenylbutadiene solute as a "wave-length shifter." The large diameter fluors can be used in such applications as: very high energy nuclear physics; measurement of total energy loss by very energetic particles; cosmic ray measurements; biophysical measurements; weapons-test applications, and aerial-survey mapping of ore deposits. Cadillac Plastic & Chemical Co., Detroit 3, Mich.

CIRCLE 39 ON PAGE 48 FOR MORE INFORMATION

New Film Gauge

This film gauge measures the plating and film thickness on conductive materials quickly and precisely. It also measures the protective covering thickness of anodic films on non-magnetic metals such as anodized aluminum, magnesium, and on organic paints, porcelain, enamel, and other non-conductive coatings. It sorts and matchs metals in accordance with their electrical conductivity and magnetic properties. Boonton Radio Corp., Boonton, N. J.

CIRCLE 40 ON PAGE 48 FOR MORE INFORMATION

Discriminator

The new Epsco Model FM-108 FM-to-Voltage converter provides ultra-stable conversion for telemetering and data processing. It avoids the necessity of correcting for component aging, thermal drift, or gain variations. It features an absolute accuracy of 0.05% and dynamic accuracy better than 0.2% for the life of the equipment. It will operate on any of the 23 standard IRTWG telemetering sub-frequencies from 400 cps to 70 kc. Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 41 ON PAGE 48 FOR MORE INFORMATION

INFRARED
the frontier frequency

(Continued from page 14)

the true measure of process efficiency.

Promise for the Military

The military budget for infrared equipment is not known. It is perhaps small by military standards, because here, too, the use is relatively new, but it is certainly growing at a tremendous rate. For infrared methods are now challenging radar in reconnaissance, warning, and fire control. It is not yet so useful for ranging, but it has a unique virtue as a basis for homing guidance. Add to this, its advantages as a passive—therefore unjammable—signal, its lighter weight and less expensive components, and its potential for becoming a more important military principle than radar becomes obvious. Consider also that radar has been thoroughly investigated and engineered—additional improvement will come at a high price because its theoretical limits are being reached. Infrared, on the other hand, is limited more by lack of engineering experience than theory. Radar, with a one-foot scanner, can separate two planes at five miles only if they are one-half mile apart. Infrared, with a three-inch scanner, can distinguish the engines on a single plane at this distance.

Open Skies

Infrared pictures of terrain from a high-flying airplane (remember the picture is of temperature differences) are remarkable for their clarity. And they offer one advantage that visible photographs and radar maps do not. To the latter, a power plant and a warehouse of similar size are indistinguishable, but to infrared, the power house looks like a search light. Even the effluent water from an industrial site would 'brighten' the adjacent stream which received it. It is quite possible that it is this aspect of reconnaissance which permits the President's proposals for aerial inspection to have value.

Infrared for Missiles

And if a hot building looks like a searchlight to infrared, its use as a homing guidance is obvious. The first such device, the Navy's Sidewinder homing missile, is reputed to have knocked the flare off a plane's wing tip, and to have climbed up the tailpipe of a jet engine. Such missiles are, of course, subject to some decoying and the sun's radiation is a worry.

Military use of infrared is of greatest value at high altitudes where there is less water vapor and carbon dioxide to absorb the target radiation. Here, with the increasing speed of missiles, its value in warning and counterattack will pay off. The higher the speed of the missile, the more warning or directing time is required. The higher the speed of the missile, the greater is its skin temperature from air friction, and the more susceptible is it to infrared detection. Since infrared detection increases very rapidly with the target's increase in temperature, the range of detectability increases faster than the speed involved. Very possibly our major warning and counter measure for ICBM will be on infrared principles.

Retreating Frontiers

The chemical and military aspects of infrared represent its major potential. There are, in addition, a host of scattered applications dependant on combining in various ways its characteristics of radiation and heating.

Pyrometry is the general term for temperature measurement by calibra-

Dr. Van Zandt Williams, Vice President and General Manager, Instrument Division of the Perkin-Elmer Corporation became interested in infrared spectroscopy when that technology was in its infancy. After receiving his doctorate (Physics) from Princeton in 1941, Dr. Williams became Group Leader in charge of infrared spectroscopy at the Stamford Research Laboratories of the American Cyanamid Corporation. He was later appointed Assistant Director of the Physics Division. He designed an infrared instrument which became the prototype in its field. Dr. Williams holds membership in a number of learned societies.

tion of the infrared radiation emitted by an object. It is a very useful method where the object being measured cannot be reached by thermocouple contact. Thus, furnace melts in the metals industry are measured by infrared. Railroad car hot boxes are detected by an infrared device in the roadbed as a train passes over it. Infrared is being applied where spinning turbines and jet engine exhausts are being studied. It has its use, too, in fire detection. One pertinent application was found by a college professor who accepted the assignment from an agricultural association to try to correlate sterility in cattle as a function of the temperature of bulls' scrota. He was successful, and he never got within 50 feet of a bull. Along the same lines, and, an outcropping of military reconnaissance developments, are commercial devices for taking a temperature picture of an object. This is used to determine heat loss from a structure, or output from a radiant heating device.

Infrared radiation has a further useful characteristic: its long wavelength, as compared to visible or ultraviolet light, tends to penetrate the material it strikes before it is converted to heat. From this, we get infrared cooking, paint drying, and even blistering-off of tomato skins as a substitute for mechanical peeling.

The most bizarre and singular application of this heat generating quality is perhaps the one used by a medical researcher who wanted to devise a method for inflicting pain on patients in a quantitative fashion in order to measure the effectiveness of certain analgesics. His method was to focus infrared onto the patient's forehead and measure the pain infliction by the source intensity. This naturally raises the obverse question of lie detection. A subject sitting in a chair strapped-up with electrodes faces quite a psychological barrier. Would not an unseen pyrometer measuring skin temperature be a better approach?

Wherever one looks, there is infrared application; the somewhat esoteric one of the chemical industry, the awful but necessary application of the military, and the just generally useful ones that inevitably result from the interplay of heat and infrared. It is a most basic phenomenon in the world—one which will have ever new usefulness. END

psychological testing

(Continued from page 25)

Testing the Test

The third step is to choose and administer the tests. Methods to measure most human characteristics are already available. We have tests to measure aptitudes, intelligence, personality, technical competence, sales abilty, clerical ability, imagination and many other attributes. Psychologists have made great strides in developing and refining these tests. Such tests are presently available and are being used in different organizations.

In administering these ready-made tests the basic problem is to determine whether or not the high group —that is, the group determined previously on the criterion as being presently successful on the job—*does* differ significantly in its test response from the low group. In other words, at this stage, you are testing the tests. If the test results do not correlate significantly with the present measure of job success, then the tests, not the people, have failed. When this happens, both criterion and test must be re-examined. However, a good test is emerging when the responses differentiate the two groups.

Really, then, we are saying that in selecting personnel for the future, one looks for men who resemble those who have already succeeded in the company. This is the core of industrial testing. Predictions of success from these tests are based on applying them to new candidates after they have been properly worked out on older employees. Psychological tests can help in a selection process if the aim is to pick men like the good ones now on the staff and screen out types similar to those who are not succeeding now in the organization.

Putting Results in Deep Freeze

The final step is what we call cross-validity. The job analysis has been completed, the high and low groups established, the skills and aptitudes tested. Up to this point you have not used these test results to hire, fire, or promote anyone. The individuals taking the test have served as an experimental group. They have helped to set up the testing program for the future.

Now you are ready for the fourth and most important step. The test results are put away in a file or safe. The personnel officer continues to select new candidates by the old techniques. But, though he does not hire on the basis of the tests, he does require that all new candidates take them. Then after three or six months, the psychologist compares the performance records of the new men with their test records. He determines which of the new men he would have eliminated and which ones he would have retained based on interviews and tests. If the tests have done the job, the psychologist will be able to increase the batting average about and beyond what any one individual could have done without the test scores.

For the Long Pull

This may sound like a costly and time consuming procedure, but you have to face the fact that a good testing program costs money.

Is it worth the expenditure? The psychologist's answer is simply this. Just calculate the amount of money lost by putting the wrong man in a critical spot. Or try to compute the cost of not having a reservoir of potentially promotable men. In the tight manpower market which industry faces in the next 25 years, the future security of any company may well hinge on its ability to select the right men.

Some companies try to do this selection job with packaged tests, that is, tests which have been developed for mass consumption. These are fine at lower levels. However, avoid the "prepared mix" at the middle and top management level unless you have competent guidance helping in the adaptation. There is no substitute for a test tailormade to the specific needs of your company.

Testing Controversies

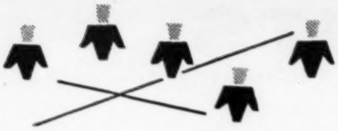
One of the frequent arguments raised against this type of selection test is that it builds into the organization too many carbon copies of the present leaders. Psychologists themselves share in this reservation. However, this will not be a serious problem if the testing is rechecked. Any testing program must build into it some methods for re-checking, re-evaluation and reformulation of goals. Maybe ten years from now the company will need more or less aggressive men; maybe more analytical men; maybe less critical; maybe more energetic, possibly less. The important point is that if the company freezes in a method, it is likely to be trapped in the belief that the final job is complete when actually it has just started.

In summary let me offer some points about psychologists. First, they try to be cautious. They make no claim that testing is a panacea for all personnel problems. It's merely a way of improving one's batting average. It supplements, and does not replace one's subjective judgment in the selection process.

Second, before the company puts a program into the hands of a psychologist, it's wise to check his professional qualifications. Here are some rules of thumb to assist in the choice of a competent practitioner.

- Make certain that the psychologist is a *qualified* member of the American Psychological Association. There are also different levels of membership. Information about any individual or consulting firm can easily be obtained by writing to the Executive Secretary of the American Psychological Association, 1333 Sixteenth Street N. W., Washington, D. C.
- Be wary of the qualifications of anyone who overpromises, who guarantees too much. A competent consultant "consults himself out of a job", so to speak. He tries to help set up the machinery so that it can run with a minimum of servicing. He comes in, sets it up, does the job and leaves. END

Industrial psychologist Dr. Mortimer R. Feinberg is an Assistant Professor, Baruch School of Business and Public Administration of the City College of New York. He is also Industrial Psychology Editor of the Research Institute of America, and has served as a consultant to the US Air Force, Marine Corps, and Navy, to GE and Standard Oil of N.J. Dr. Feinberg is the author of a newly completed management manual for training supervisors in the principles of human relations.



TECHNICAL MANAGEMENT *(Cont. from p. 9)*

have they worked out? What are the problems involved? Please write in so that by means of this column we can obtain much better relations and greater effectiveness in our efforts.

More on Professional Ethics

The case of John Hull elicited the following analysis from John M. McEwen, Technical Director of Kraft Mill, Weyerhaeuser Pulp Div., Everett, Washington.

"The problem of John Hull was a good one. Professor Meyer's analysis ably states one viewpoint on the case. It may be of interest to bring out another.

"John Hull is the top paid man of his group. There are few technical positions in industry where the supervisor of a group is paid more than twice the top paid man under him. Thus the job offered John Hull probably pays more than you, his boss, are paid.

"The problem states that John Hull needs several years of guidance under a mature leader. Is it not possible that he may further develop under wise leadership in his new position? It certainly isn't in Mr. Ingle's best interest to send a boy to do a man's job. He must feel that this clever and imaginative engineer will be worth what he pays him.

"If John came to me I would discuss the relative advantages and disadvantages of the two positions from his viewpoint. Since he is a good man I would certainly emphasize the advantages of staying with the firm. If it were to his advantage to go, I would let him go with my best wishes. Such a decision should be made with more knowledge than was given in the problem.

"As long as Hull talked over the matter before deciding and had sound reasons for going, I would recommend rehire. If he is so good we want him now, why won't he be even better with some experience in another organization under his belt? Any actual rehire would be made only if he were clearly better qualified for the position in question than any available man in our organization.

"Hull's action in discussing the proposed change with his boss seems quite ethical. Is a professional engineer supposed to automatically decline any position other than one offered by his present employer? It would appear to be unethical to recommend against Hull's rehire if the only reason were to punish him for leaving. If you felt his decision was unsound and he might make similar unsound decisions for your company it would seem to be entirely ethical to recommend against rehire.

"The question of ethics for Mr. Ingle and the new company seem to revolve around whether his type of talent renting agency performs a needed service in our free enterprise economy. If it is a coverup for uneconomical body-snatching, neither would seem ethical and John Hull should not become involved unless he is looking for some short and bitter experience. If Mr. Ingle's company provides temporary help for special engineering projects, it would seem to be a needed ethical consulting-type service." END

COMPONENTS

Power Transistors

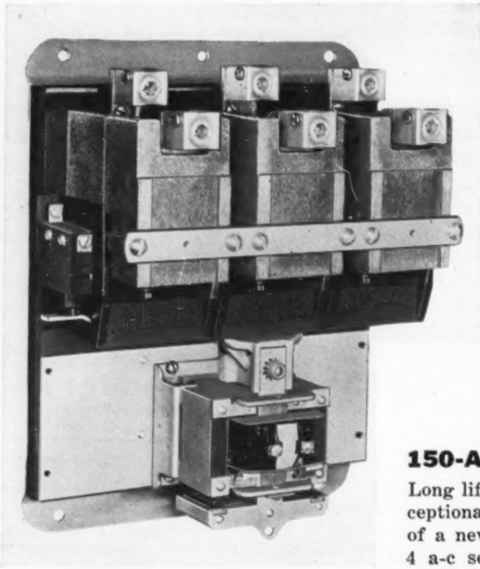
Power transistors capable of switching a load in excess of 1kw now are in mass production. The power needed to control a load of 1kw with a transistor is only 1 watt. Advantages of using the transistor as a switch are that it is possible to switch an electrical current from a considerable distance using only thin wiring, and arcing at the switch is eliminated resulting in much longer switch life. A conventional switch will deteriorate in use while the transistor, because of the absence of arcing, will not wear. It is possible to convert d-c into a-c with such a switch. Delco Radio Div. of General Motors, Kokomo, Ind.

CIRCLE 50 ON PAGE 48 FOR MORE INFORMATION

Miniature Power Supply

This tiny silver-zinc battery is finding wide use where an instantly available source of closely-related electric power is needed, or for emergency use when primary power fails. The device has a very long shelf life, being shipped dry, but carrying its own electrolyte supply inside the sealed case. In response to a mementary electrical signal, the fluid is transferred to the battery cells, producing full power output within one-half second. The unit produces 28 volts at 700 watts for two minutes, operates at ambient temperatures between —65° and 240°F; is unaffected by altitude and needs no venting. Frank R. Cook Co., ElectroChemical Div., 36 S. Santa Fe Dr., Denver 23, Col.

CIRCLE 51 ON PAGE 48 FOR MORE INFORMATION



Thermostat Metals

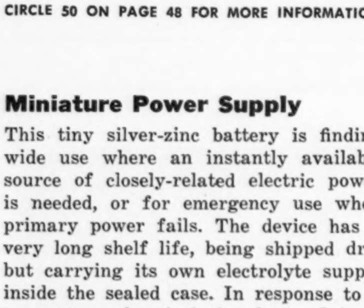
Two new thermostat metals are designed for use in instrumentation. One of the metals has good electrical resistivity and corrosion resistance, with a useful deflection range of —100° to 700° F, with maximum sensitivity from 0 to 300°F. The other has a wide range of linear deflections between —50° and 700°F. Maximum sensitivity is 200° to 600°F. It combines a high deflection with a high torque rate. Both are produced in thicknesses down to 0.001", widths down to 0.093", in coils or lengths cut to order. American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.

CIRCLE 52 ON PAGE 48 FOR MORE INFORMATION

150-Amp A-C Contactor

Long life, simple solenoid design and exceptional compactness are key features of a new 150-amp standard NEMA size 4 a-c solenoid contactor. Designed primarily for use in motor starters and controllers, it may be applied as a mainline, accelerating or reversing contactor. Heavy inrush currents are handled by sintered silver-cadmium-oxide main contacts without welding or excessive pitting. Stationery contacts are of one-piece design with heavy duty lug, accessible from the front. Four auxiliary side-mounted units with NO, NC, or DT contacts are optional. Ward-Leonard Electric Co., Mount Vernon, N.Y.

CIRCLE 54 ON PAGE 48 FOR MORE INFORMATION



Corrosion Resistant Valve

A Y-globe valve with full flow passage, made entirely of rigid polyvinyl chloride, has been designed for corrosive fluids. It is both non-toxic and non-corroding, assuring fluid purity. A special bonnet and gland nut design provides an absolutely leak proof unit. The valve operates successfully at pressures up to 150 psi, at 75°F. Weighing only about 1/6 as much as a similar brass or steel valve, it reduces handling and installation costs. Walworth Co., 60 E. 42nd St., N.Y.C.

CIRCLE 53 ON PAGE 48 FOR MORE INFORMATION

Insulated Terminals

Terminal board breakage can be eliminated in the assembly and performance of a wide range of electronic gear, through the development of a line of insulated terminals, applicable to airborne electronic components, missile systems, radar, printed circuits, computers and other precision equipment, the insulated terminals are designed for installation directly into metal chassis. According to the manufacturer, its chassis-mounted terminals remove the need for terminal boards; and they conform to the most stringent military specifications. Globe Electrical Manufacturing Co., Gardena, Calif.

CIRCLE 55 ON PAGE 48 FOR MORE INFORMATION

Jet Engine Alloy

A new high-strength alloy is made for key jet engine components operating in the 1200-1400°F temperature range. A high-strength iron base alloy with a strength-to-weight ratio 25-40 per cent better than comparable materials, J1300's operating temperature is 100°F higher than materials now in use. While making possible a reduction of several hundred pounds in overall engine weight, J1300 pushes jet performance beyond that obtainable with currently used materials. Flight Propulsion Laboratory Dept., Aircraft Gas Turbine Division, General Electric Co., Cincinnati 15, O.

CIRCLE 56 ON PAGE 48 FOR MORE INFORMATION

Miniature Indicator Lights

Miniature indicator lights with neon or incandescent lamps and requiring a mounting hole only ⅜" diam., are easily replaced from the front of the mounting panel. The units are useful in computers, telemetering equipment, control systems and other applications where miniaturization and high reliability are essential. Lenses are of plastic; a round-nosed style for the neon light, and a flat lens (which may be had with special read-out markings,) for the incandescent lamp. Lens colors are red, amber or clear for neon lamp; incandescent comes in the same colors plus blue and green. Materials are moisture and corrosion resistant. Bulb life exceeds 10,000 hours, and ratings are 1/25 watt for the neon and 6, 12-14 or 24-28 volt for the incandescent lamps. Eldema Corp., El Monte, Calif.

CIRCLE 58 ON PAGE 48 FOR MORE INFORMATION

Data Reduction System

These digital timing generators and magnetic tape search units provide automatic highspeed access to selected data in Ampex Recorders and similar multichannel magnetic tape instrumentation systems. The Digital Timing Generator generates numerically coded timing signals, records them on magnetic tape, provides a precise digital index in terms of elapsed time, and visually displays exact time in hours, minutes and seconds as illuminated digits. The Magnetic Tape Search Unit automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. Both models mount in RETMA standard 19" relay racks. Hycon Eastern, Inc., 75 Cambridge Pkwy., Cambridge 42, Mass.

CIRCLE 59 ON PAGE 48 FOR MORE INFORMATION

Miniature Isolator

This new 100 Kw resonant absorption miniature Ku band ferrite isolator insures optimum magnetron spectrum and power output by furnishing isolation between magnetron and RF energy reflected from the line mismatches. The unit operates over a frequency range of 16,000 to 17,000 Mcs with a minimum isolation of 15 db and a maximum insertion loss of 0.4 db. It will safely handle 100 Kw of peak power and 100 watts of average power into a 2 to 1 mismatch load. When it is terminated with a matched load, it presents an inherent VSWR to the magnetron of the order of 1.10. Operating characteristics are guaranteed under vibration specification MIL-E-5272A and over temperatures that range from —55° to plus 100°C. Airtron, Inc., 1103 W. Elizabeth Ave., Linden, N.J.

CIRCLE 60 ON PAGE 48 FOR MORE INFORMATION

To refill your reservoir of originality

The Gordon Research Conferences

"I wish that I could just get away to think." That's a plaint that R/E's editors hear often in research and development circles. And understandably so. For the pressure on R/D projects, the explosive rate of growth of technological knowledge, the new scientific frontiers which are opening up, all contain elements of frustration for thoughtful scientists. It takes time—relaxed time—to assimilate the meaning and import of significant research accomplishments and trends.

But early next month some of the world's top-ranking scientists will break their day-to-day routines to do just that. They'll journey quietly and probably unnoticed to secluded retreats in New Hampshire. And there, with their scientific peers, they will explore the meaning of recent research in dozens of fields; they will promulgate new theories; they will dissect old ones; they will chat informally about the shape of things to come and appraise the nature and dimensions of the frontiers of science. For next month the Gordon Research Conferences will begin again—and will, as in the past, be host to scientists from the 48 States and some 30 foreign countries.

Oddly enough, although the Gordon Research Conferences have been in existence for 25 years, and even though the roster of attending scientists is impressive (e.g. such noteworthy men as Baekeland, Langmuir, Fermi, Urey, and Seaborg have been frequent conference participants), they have not been particularly well known. That, in part, has stemmed from the nature of the Conferences and their secluded sites. In part, too, perhaps it has derived from policy—no papers are issued for publication by the Conferences. (As a matter of fact, in the interest of promoting free discussion, no record is kept of what is said at any Conference). But because the Conferences are unique, and because they are in line with R/E's past efforts to increase communications opportunities for leaders in R/D, the editors have interviewed Dr. W. George Parks, Director of the Conferences, and prepared this brief report on the forthcoming program.

One novel aspect of the Conferences—and one which really has been the foundation of the entire non-profit organization—is informality. And informality in more than one sense. In the first place, attendance at any one Conference is limited to 100 scientists. (The 100 conferees are selected from the applications received on the basis of what each might be expected to contribute to the discussions. A conscious effort is made, too, for balance between industrial, government and academic attendance so that each group will benefit by exchanging experience and views with the other).

The fact that the group is deliberately kept relatively small contributes, of course, to informality and optimum communications.

Too, the presentation of formal papers is discouraged. Rather, the Conference Chairman is expected to act as a discussion leader. Moreover, lecture platforms and row-on-row of carefully attired "listeners" are verboten. Instead, the Conferees lounge in a circle of club chairs and sofas and seldom does their formal dress exceed open-necked sport shirts and slacks.

Each week during the 12-week period, three Conferences are held concurrently. But each is at a different site: New London, Meriden and New Hampton, New Hampshire. And each operates autonomously. The Conferees at one are not concerned with the subject matter being discussed at another. However, at each there is a common program pattern: Every morning there is a "formal" or organized session. The afternoon is unscheduled—scienitsts usually golf, swim, ride, play tennis, hike, or as is often the case, just sit around under the trees to talk over the morning's session. They reconvene after dinner in the evening for further discussions (which frequently become so intense that they carry on well into the early hours of the next morning). So it goes—from Monday through Friday noon.

That will be the pattern this summer. It will be the pattern followed in the older Conferences and the newer ones (e.g. Metals at High Temperatures, Cell Structure, Relaxation Phenomena of Liquids). But always the emphasis will be as it has long been—exploring the frontiers of science, earnestly, informally, unhurriedly and fruitfully.

With time to think.

WM. H. RELYEA, JR.,
Publisher

Program of Conferences

Colby Junior College

Petroleum, June 10-14; Lawrence Flett, chairman, P. D. Caesar, vice chairman. Sessions on: Liquid Phase Oxidation and Antioxidants; Alkylation of Isoparaffins and Olefins; Hydrogen Refining; Polyethelene.

Catalysis, June 17-21; R. L. Burwell, Jr., chairman, Vladimir Haensel, vice chairman.

Separation and Purification, June 24-28; Karl Kammermeyer, chairman, L. C. Craig, vice chairman.

Polymers, July 1-5; W. E. Cass, chairman, T. G. Fox, vice chairman.

Textiles, July 8-12; H. A. Secrist, chairman, E. I. Valko, vice chairman.

Corrosion, July 15-19; W. D. Robertson, chairman, J. E. Draley, vice chairman. Sessions on: Hydrogen Absorbtion and Embrittlement; Structure, Dependent Corrosion, and Oxidation; Effect of Radiation on Corrosion; Corrosion in Water at High Temperatures; Stress Corrosion Cracking of Stainless Steel.

Instrumentation, July 22-26; Axel H. Peterson, chairman, N. B. Nichols, vice chairman.

Elastomers, July 20-Aug. 2; E. E. Gruber, chairman, E. B. Newton, vice chairman.

Medicinal Chemistry, Aug. 5-9; K. E. Hamlin, chairman, M. B. Chenoweth, vice chairman.

Vitamins and Metabolism, Aug. 12-16; George W. Kidder, chairman, Lemuel D. Wright, vice chairman.

Food and Nutrition, Aug. 19-23; Harry Spector, chairman, Robert H. Silber, vice chairman. Sessions on: Antibiotics in Food Preservation; Fat Metabolism and Atherosclerosis; Advances in Protein Nutrition; Preservation of Food by Ionizing Radiations; Operations Research.

Cancer, Aug. 26-30; Arthur Kirschbaum, chairman, Hans Schlumberger, vice chairman.

New Hampton School

Chemistry and Physics of Liquids Relaxation Phenomena, June 10-14; T. A. Litovitz, chairman, Ernest B. Yeager, vice chairman.

Metals at High Temperatures, June 17-21; Nicholas J. Grant, chairman, John Frye, vice chairman.

Coal, June 24-28; John Mitchell, chairman, Alfred R. Powell, vice chairman; Carbonization of Coal and Nature and Structure of Cokes.

Proteins and Nucleic Acids, July 1-5; C. B. Anfinsen, Jr., chairman, Paul C. Zamecnik, chairman-elect. Sessions on: Covalent Structure of Proteins; Theoretical and Experimental Aspects of the Tertiary Structure of Proteins in Solution; Structure of Proteins in Solution; Protein Structure in Relation to Function; Structure in Relation to Function; Genetic Basis of Protein Structure; Molecular Basis of Evolution.

Radiation Chemistry, July 8-12; C. J. Hochanadel, chairman, W. H. Hamill, vice chairman. Sessions on: Primary Processes; Gaseous Ions and Their Reactions; Gas Phase Reactions; Organic Systems; Polymerization and Polymers; Aqueous Systems.

Organic Reactions and Processes, July 15-19; Harvey J. Taufen, chairman, Richard T. Arnold, chairman-elect.

Microbiological Deterioration, July 22-26; A. D. Lohr, chairman. Sessions on: Structure-activity Relationships Among Antimicrobial Substances; Deterioration Problems Posed by Soil Microorganisms; Behavior of Fungicides after Application; Microbiological Deterioration Problems in the Marine Environment.

Statistics in Chemistry and Chemical Engineering, July 29-Aug. 2; John C. Whitwell, chairman, Frank Wilcoxon, vice chairman.

Steroids and Related Natural Products, Aug. 5-9; J. Fried, chairman, G. Stork, vice chairman.

Analytical Chemistry, Aug. 12-16; E. W. Balis, chairman, Louis Gordon, vice chairman.

Inorganic Chemistry, Aug. 19-23; S. Y. Tyree, Jr., chairman, H. B. Ionassen, vice chairman. Sessions on: Crystal Field Theory Applied to Metal Coordination Compounds; Mechanisms of Substitution Reactions of Coordination Compounds; Applications of Physical Methods to Inorganic Chemistry; High-temperature Chemistry.

Adhesion, Aug. 26-30; D. K. Rider, chairman, G. W. Koehn, vice chairman.

Kimball Union Academy

Lipide Metabolism, June 10-14; Warren M. Sperry, chairman. Sessions on: Chemistry and Structure of Lipoproteins; Lipid Transport; Unsaturated Fatty Acids and Fat Metabolism; Fat Synthesis; Cholesterol Metabolism.

Cell Structure and Metabolism, June 17-21; A. W. Pollister, chairman, M. J. Moses, vice chairman. Sessions on: Metabolism of Chromosomes; Metabolism of the Interphase Nucleus; Protein and Nucleic Acid Synthesis in the Cytoplasm; Structure and Metabolism of Chloroplasts; Mitochondria and Golgi Apparatus.

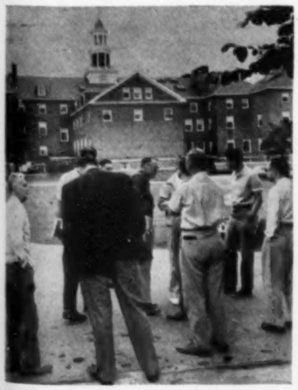
Nuclear Chemistry, June 24-28; Earl K. Hyde, chairman, Nathan Sugarman, vice chairman.

Solid-State Studies in Ceramics, July 1-5; H. O. Thurnauer, chairman, M. L. Kronberg, vice chairman.

(Continued on page 46)

Frontiers of technical knowledge are extended through a free and informal exchange of ideas by experts. Discussions often move from the lecture hall and classroom to the campus and various lounges available to conferees.

Photos through the courtesy of George Woodford, *Business Week*



An Atomic Glossary

Accelerator. A device for imparting very high velocity to charged particles such as electrons or protons. These fast particles can penetrate matter and are known as radiation. They are used to study the structure of the atom.

Activation. Making a substance artificially radioactive in an accelerator such as a cyclotron or by bombarding it with neutrons.

Alpha Particle (Alpha Ray, Alpha Radiation). A small electrically charged particle of very high velocity thrown off by many radioactive materials, including uranium and radium. It is identical with the nucleus of a helium atom and is made up of two neutrons and two protons. Its electric charge is positive and twice as great as that of an electron.

Atom. The building block of nature. Consists of an inner core (nucleus) surrounded by electrons which rotate around the nucleus like the planets around the sun.

Atomic Energy. Energy released in nuclear reactions. Of particular interest is the energy released when a neutron splits an atom's nucleus into small pieces (fission) or when two nuclei are joined together under millions of degrees of heat (fusion).

Atomic Number. The number of protons (positively charged particles) found in the nucleus of an atom. All elements have different atomic numbers.

Atomic Weight. The atomic weight is approximately the sum of the number of protons and neutrons found in the nucleus of an atom. The atomic weight of oxygen, for example is approximately 16 (actually it is 16.0044)—it contains 8 neutrons plus 8 protons.

Atom Smasher. An accelerator that speeds up atomic and sub-atomic particles so that they can be used as projectiles to blast apart the nuclei of other atoms.

Beta Particle (Beta Radiation). A small electrically charged particle thrown off by many radioactive materials. It is identical with the electron and possesses the smallest negative electric charge found in nature. Beta particles emerge from radioactive material at speeds close to the speed of light.

Betatron. A large doughnut-shaped accelerator in which electrons (beta particles) are whirled through a changing magnetic field gaining speed with each trip and emerging with high energies. Energies of the order of 100 million electron volts have been achieved. The betatron produces artificial beta radiation.

Bev. A billion electron volts. An electron possessing this much energy travels with a speed close to that of light—186,000 miles a second.

Bevatron. A huge circular accelerator such as the one located at the University of California. Protons are whirled through the 160-foot doughnut between the poles of a magnet weighing 13,000 tons. It is designed to produce energies of 10 billion electron volts.

Bombardment. Shooting neutrons, alpha particles and other high energy particles at atomic nuclei, usually in an attempt to split the nucleus or to form a new element.

Breeder. A reactor which is producing more atomic fuel than it is consuming. A nonfissionable isotope, bombarded by neutrons, is transformed into a fissionable material, such as plutonium, which can be used as fuel.

Cerenkov Radiation. An eerie blue glow given off by electrons traveling in a transparent material such as water.

Chain Reaction. When a fissionable nucleus is split by a neutron it releases energy and one or more neutrons. These neutrons split other fissionable nuclei releasing more energy and more neutrons making the reaction self-sustaining.

Cloud Chamber. A glass-domed chamber filled with moist vapor. When certain types of atomic particles pass through the chamber they leave a cloud-like track much like the vapor trail of a jet plane. This permits scientists to see these particles and study their motion.

Cobalt-60. A radioactive isotope of the element cobalt. Cobalt-60 is an important source of gamma radiation and is used widely in research.

Compton Effect. The glancing collision of a gamma ray with an electron. The gamma ray gives up part of its energy to the electron.

Control Rod. A rod used to control the power of a nuclear reactor. The reactor functions through the splitting of nuclear fuel by neutrons. The control rod absorbs neutrons which would normally split atoms of the fuel. Pushing the rod in reduces the release of atomic power; pulling out the rod increases it.

Converter. A reactor which uses one kind of fuel and produces another. For example a converter charged with uranium isotopes might consume Uranium-235 and produce plutonium from Uranium-238.

Core. The heart of a nuclear reactor where the nuclei of the fuel fission (split) and release energy. The core is usually surrounded by a reflecting material which bounces stray neutrons back to the fuel.

Cosmotron. A huge accelerator, one of the atomic guns, located at Brookhaven National Laboratory. It speeds-up particles to the billion electron volt range.

Critical Mass. The amount of nuclear fuel necessary to sustain a chain reaction. If too little fuel is present too many neutrons will stray and the reaction will die out.

Curie. A measure of the rate at which a radioactive material throws off particles. The radioactivity of one gram of radium is a curie.

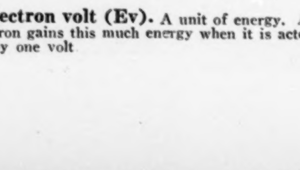
Cyclotron. A particle accelerator. In this atomic merry-go-round atomic particles are whirled around in a spiral between the ends of a huge magnet gaining speed with each rotation in preparation for their assault on the target material.

Decay. When a radioactive atom disintegrates it is said to decay. What remains is a different element. An atom of polonium decays to form lead, ejecting an alpha particle in the process.

Deuterium Heavy Hydrogen. The nucleus of heavy hydrogen is a deuteron. It is called hydrogen because it weighs twice as much as ordinary hydrogen.

Deuteron. The nucleus of an atom of heavy hydrogen containing one proton and one neutron. Deuterons are often used as atomic projectiles.

Dosimeter (Dose Meter). An instrument used to determine the radiation dose a person has received.



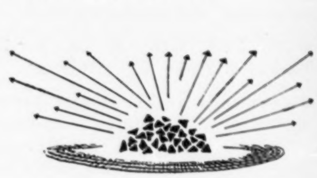
Electron. A minute atomic particle possessing the smallest amount of negative electric charge found in nature. In an atom the electrons rotate around a small nucleus. It is only about a two-thousandth of the mass of a proton or neutron.

Electron volt (Ev). A unit of energy. An electron gains this much energy when it is acted upon by one volt

Fission. The splitting of an atomic nucleus into two parts accompanied by the release of a large amount of radioactivity and heat. Fission reactions occur only with heavy elements such as uranium and plutonium.

Fusion. The joining of atomic nuclei to form a heavier nucleus, accomplished under conditions of extreme heat (millions of degrees). If two nuclei of light atoms fuse, the fusion is accompanied by the release of a great deal of energy. The energy of the sun is believed to be derived from the fusion of hydrogen atoms to form helium.

Gamma Rays (Gamma Radiation). The most penetrating of all radiations. Gamma rays are very high energy X-rays.



Geiger Counter. A gas-filled electrical device detects the presence of radioactivity by counting the formation of ions.

Half-Life. A means of classifying the rate of decay of radioisotopes according to the time it takes them to lose half their strength (Intensity). Half lives range from fractions of seconds to billions of years. A radioactive material loses half its strength when its age is equal to its half-life.

Heavy Hydrogen Same as deuterium.

Heavy Water Water which contains heavy hydrogen (deuterium) instead of ordinary hydrogen. It is widely used in reactors to slow down neutrons.

Ion. Usually an atom which has lost one or more of its electrons and is left with a positive electrical charge. There are also negative ions, which have gained an extra electron.

Ionization Chamber. A device roughly similar to a geiger counter and used to measure radioactivity.

Isotope. Two nuclei of the same element which have the same charge but different masses are called isotopes. They contain the same number of protons but a different number of neutrons.

Kev Kilo. Electron volts or 1,000 electron volts. A unit of energy.

Linear Accelerator. A machine for speeding up charged particles such as protons. It differs from other accelerators in that the particles move in a straight line at all times instead of in circles or spirals.

Meson. A particle which weighs more than the electron but generally less than the proton. Mesons can be produced artificially. They are also produced by cosmic radiation from outer space. Mesons are not stable—they disintegrate in a fraction of a second.

Mev. Million electron volts.

Milliroentgen. One one-thousandth of a roentgen. A unit of radioactive dose.

Moderator. A material used to slow neutrons in a reactor. These slow neutrons are particularly effective in causing fission. Neutrons are slowed down when they collide with atoms of light elements such as hydrogen and carbon, two common moderators.

Neutron. One of the three basic atomic particles. The neutron weighs about the same as the proton and, as its name implies, has no electric charge. Neutrons make effective atomic projectiles.

Nuclear Bombardment. The shooting of atomic projectiles at nuclei usually in an attempt to split the atom or to form a new element.

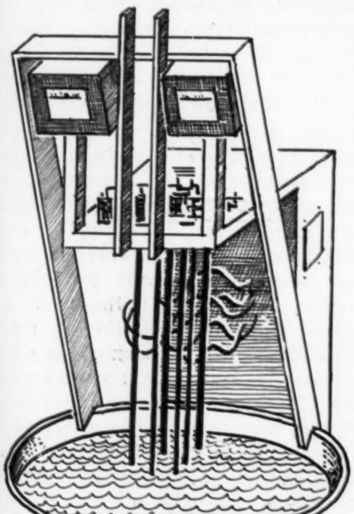
Nuclear Reaction. Result of the bombardment of a nucleus with atomic or sub-atomic particles or very high energy radiation. Possible reactions are emission of other particles or the splitting of the nucleus (fission). The decay of a radioactive material is also a nuclear reaction.

Nucleonics The application of nuclear science and techniques in physics, chemistry, astronomy, biology, industry and other fields.

Nucleus. The inner core of the atom. It consists of neutrons and protons tightly locked together.

Pair Production. The conversion of a gamma ray into a pair of particles—an electron and a positron. This is an example of direct conversion of energy into matter according to Einstein's famous formula: $E = mc^2$.

Photon. A bundle (quantum) of radiation. Constitutes, for example, X-ray and light. In certain processes gamma rays behave as photons.



Pile. A nuclear reactor. Called a pile because the earliest reactors were piles of graphite blocks and uranium slugs.

Plutonium. A heavy element which undergoes fission under the impact of neutrons. It is a useful fuel in nuclear reactors. Plutonium does not occur in nature.

Positron. A particle which has the same weight and charge as an electron but is electrically positive rather than negative. The positron's existence was predicted in theory years before it was actually detected. It is not stable in matter.

Proton. One of the basic particles of the atomic nucleus (the other is the neutron). Its charge is as large as that of the electron, but positive.

Q-Value. The energy liberated or absorbed in a nuclear reaction.

Radiation. (radioactivity). The emission of very fast atomic particles or rays by nuclei. Some elements are naturally radioactive while others become radioactive after bombardment with neutrons or other particles. The three major forms of radiation are alpha, beta and gamma.

Radioisotope. A radioactive isotope of an element. A radioisotope can be produced by placing material in a nuclear reactor and bombarding it with neutrons. Radioisotopes are important peacetime contribution of atomic energy.

Reactor. An atomic furnace. In a reactor, nuclei of the fuel undergo fission under the influence of neutrons. The fission produces new neutrons and hence chain reaction. This releases large amount of energy, which is removed as heat to make steam for use in generation of electricity.

Roentgen. A unit of radioactive dose, or exposure.

Scintillation Counter. A device for counting atomic particles by means of tiny flashes of light (scintillations) which the particles produce when they strike certain crystals.

Slug. A fuel element for a nuclear reactor, a piece of fissionable material. The slugs in large reactors consist of uranium metal coated with aluminum to prevent corrosion.

Synchrotron. An accelerator used to achieve higher velocities for atomic particles than is possible in a conventional cyclotron.

Thermonuclear Reactions. A fusion reaction —one in which two light nuclei combine to form a heavier atom, releasing a large amount of energy. This is believed to be the sun's source of energy. It is called thermonuclear because it occurs only at a very high temperature.

Thorium. A heavy element. When bombarded with neutrons thorium changes into uranium becoming fissionable and thus a source of atomic energy.

Tracer. A radioisotope which is mixed with a stable material. The radioisotope enables scientists to trace the material as it undergoes chemical and physical changes.

Tritium. Often called hydrogen three. Extra heavy hydrogen whose nucleus contains two neutrons and one proton. It is three times as heavy as ordinary hydrogen and is radioactive.

Unstable. All radioactive elements are unstable since they emit particles and decay to form other elements.

Uranium. A heavy metal. The two principal isotopes of natural uranium are U-235 and U-238. U-235 has the only readily fissionable nucleus which occurs in appreciable quantities in nature, hence its importance as nuclear fuel. Only 1 part in 140 of natural uranium is U-235.

Van de Graff accelerator. An electrostatic generator—a particle accelerator. To obtain the voltage, static electricity is picked up at one end of the machine by a rubber belt and carried to the other end where it is stored.

X-ray. Highly penetrating radiation similar to gamma rays. Unlike gamma rays, X-rays do not come from the nucleus of the atom but from the surrounding electrons. They are produced by electron bombardment. When these rays pass through an object they give a shadow picture of the denser portions.

Z. Symbol of atomic number. An element's atomic number is the same as the number of protons found in one of its nuclei. All isotopes of a given element have the same Z number.

From 101 ATOMIC TERMS and What They Mean.
Esso Research and Engineering Company

BOOKS

AN INTRODUCTION TO JUNCTION TRANSISTOR THEORY

By R. D. Middlebrook

Reviewed by Harwick Johnson, R.C.A. Laboratories, Princeton, N.J.

The development of a practical yet adequate small-signal equivalent circuit for the bipolar junction transistor has been the subject of many publications since the invention of the transistor. Such a development is also the culmination of this book intended to lead the electronic engineer from semiconductor physics through junction transistor theory to an equivalent circuit suitable for use in the design of small signal amplifiers.

The discussion of pertinent semiconductor physics, which lays the groundwork for subsequent development, is treated in a relatively basic manner for a book of this type. This treatment is handled commendably by the author. While the presentation is made with considerable generality, the reader will do well to bear in mind that the discussion applies particularly to transistor semiconductors like germanium and silicon.

Having established the basic principles, the remainder of the book is devoted to intensive and well-nigh exhaustive analyses of linear one-dimensional junction transistor theory and their reduction to small-signal equivalent circuits. With its emphasis on analysis, the book is not easy to read but must be studied. In developing the complexity inherent in the transistor, the author first analyzes in detail a first approximation, then a second, etc. Thus, one occasionally has the feeling of having covered similar ground before. Nevertheless, the analyses are detailed and complete and this book should provide a ready reference for these details.

In Chapter 13, a modified small-signal equivalent originated by the author and not previously published is presented. In essence, this consists of incorporating those extrinsic elements (notably the base-lead resistance), which are often added on to a four-pole representing the intrinsic transistor, into a standard four-pole configuration and representing the elements of the four-pole by networks of lumped elements constant with frequency. In the transformation, the physical significance of the various elements is lost and the resulting network is somewhat more complicated than that often given. However, the new configuration is said to be more convenient for the circuit engineer. The author's development stops at this point and no examples of circuit design are given.

This book is most complete with respect to linear one-dimensional junction theory and can be recommended to the serious student for this study. For this purpose the book would benefit from the inclusion of problems. Except for the introductory material this book is not for the casual reader and a comprehensive study of the junction transistor field is outside the scope of this book. No mention is made of other transistor structures such as drift transistors, unipolar transistor, hook transistors. Large signal effects are but touched upon in the final chapter.

John Wiley & Sons, Inc., N.Y.C., 1957, 296 pp.

SUBCONTRACTING POLICY IN THE AIR-FRAME INDUSTRY

By John S. Day

Reviewed by E. D. Carter, Assistant Director of Procurement, The Glenn L. Martin Company

John S. Day has been most effective, through his mix of case histories, management interviews, customer reactions, and subcontractor studies, in bringing together an interesting illumination, thought-provoking treatise on this subject.

A summation and understanding of the airframe subcontracting policy and procedures, particularly over the last fifteen years, is a must for the aircraft executives who are to establish an effective subcontracting policy of the future.

An understanding of the era through which we have passed as categorized by John Day serves to point out the necessity of a defined, purposeful, yet flexible policy, to successfully meet changing economic conditions.

The scope of the volume is broad and satisfies its purpose to blend and distill various ideas about airframe subcontracing in the past and what it must be like in the future.

The book's theme is the development of the history of airframe subcontracting and the analysis of the way this policy has developed. The main body of the text deals with the background of the airframe industry. This is followed by case histories with comments and qualifications designed to show the wide difference of policy or lack of consistent policy prevalent in the industry. This section includes such subjects as: (1) historical development of airframe subcontracting, (2) alternatives to subcontracting programs, (3) significance of legal and nonlegal influences of subcontracting policies, (4) the make or buy decisions, (5) selection of qualified sources, (6) selection of the right articles for airframe subcontracting, and (7) the role and the importance of the subcontractors' management. The closing summarizes recommendations calling upon aircraft company executives to provide a more positive policy in the future. The results to be accomplished? A more efficient company operation, a ready base for national defense, and a common basis of understanding for airframe and non-airframe producers that would redound to their mutual advantage.

SUBCONTRACTING POLICY IN THE AIRFRAME INDUSTRY provides a key to the better understanding of airframe subcontracting for the future. Reading Day's works on this subject will well serve those who are charged with the responsibility for airframe subcontracting.

Harvard University, Division of Research, Graduate School of Business Administration, 327 pp., $4.00.

ELEMENTS OF SUPERVISION, 2nd EDITION

Spriegel, Schultz and Spriegel

Reviewed by Alexander C. Grasberg, R. C. A. David Sarnoff Labs., Princeton, N. J.

Although written for the factory supervisor, there is much in this book to recommend it to the project supervisor or group leader in a research and engineering organization. This book should be useful in a training program for new supervisory personnel.

The book is written to acquaint the reader with the many facets of the supervisor's responsibility. The chapters that would be of interest to the research and engineering supervisor are those concerning the role of the supervisor in the company; the various types of organizations—their advantages and disadvantages; and the duties of the supervisor in certain administrative matters such as wage administration, merit rating, transfers, promotions, discharges, safety, and induction and orientation of new employees. The chapters entitled "Interviewing—a Skill Needed in Supervising" and "The Supervisor and Mental Health" are worthy of special mention.

Underlying each section of the book is an attempt by the authors to develop for the reader an understanding or sensitivity for individual and group behavior. This is done without the jargon and sophistication of the psychologist and in a deceptively simple style.—
John Wiley & Sons, N.Y.C., 334 pp and bibliography

. . . OF FURTHER INTEREST

Remarks on the Foundations of Mathematics

BY LUDWIG WITTGENSTEIN
The Macmillan Co., 60 Fifth Ave., NYC 11. 196 pp + index, illust. $5.75

One needs no special background in mathematics to understand and enjoy the stimulating speculations presented in this bi-lingual edition of Wittgenstein's posthumous works. Topics covered in this second volume of a series include: the nature of inference and mathematical certainty; whether a new piece of mathematics is a discovery or an invention; how the method of proof effects the meaning of what is proved; the role of mathematical truths and inferences in shaping our concepts; the derivability of mathematics from logic; and essays on Goedelian sentences, Dedekind sections, and Cantor's Diagonal procedure. Included is an analytical table of contents.

Analysis for Production Management

EDWARD H. BOWMAN, ROBERT B. FETTER
Richard D. Irwin, Inc., Homewood, Ill. 495 pages + index, illust.

Beginning with a scholarly report on the historical background of production management problems, this book leads into a thorough analysis of present-day production management techniques and controls. It explains the concepts and methods of quality control, scheduling, inventory control, size and location of plants, traffic materials handling, and a host of other aspects of the production management picture.

A great deal of the book is devoted to a clear and accurate exposition of some very recent additions to the production manager's tool kit: linear programming, statistical control, sampling inspection, and the analysis of variance.

. . . Reference Texts

The Steel Skeleton, Vol. II: Plastic Behavior and Design, by J. F. Baker, M. R. Horne, and J. Heyman, 408pp., $12.00, Cambridge University Press, New York, N. Y.

Volume I—Elastic Behavior and Design—described the experimental investigations of the Steel Structures Research Committee culminating in the formulation of its recommendations, based on elastic behavior. This volume describes the later investigations starting from 1936. Particular attention is given to instability; the behavior up to collapse of continuous stanchions and a design method for multi-story welded frames; and descriptions of plasticly designed buildings. Contains authoritative analysis coupling principles and experiments which some will call revolutionary in the design of steel structures.

Applied Electrical Measurements, by Dr. R. F. Kinard and 14 contributors, John Wylie & Sons, New York City, 600 pp., $15.00.

Adhering to the teacher-classroom approach, the author covers the basic principles of electrical measurement devices and their application to electrical and non-electrical quantities. Each subject and method of measurement is preceded by an analytical development beginning with the fundamental laws in which the particular operation is based. The approach facilitates a thorough understanding of the subject and serves as an excellent review of physical and mathematical principles which most readers have studied at one time or another but which have become more or less vague from long disuse.

Electrical measurements are covered in areas such as physics, electricity, light, heat, statics, kinetics, liquids, gases and time. Because the author and his colleagues are actively engaged in the field of instruments and measurements, and have had wide experience in research, development, manufacture and applications of all types of measuring devices, their approach will be of as much interest and use to the everyday research and development engineer as it will to the beginning student.

Introduction to Numerical Analysis, by F. B. Hildebrande, McGraw-Hill Book Co., 505 pp., $8.50.

Here is an introductory treatment of the fundamental processes of numerical analysis compatible with the expansion of the field brought about by the development of the modern high-speed calculating devices. The book takes into consideration that very substantial amounts of computation will continue to be performed on desk calculators and that familiarity with this type of computation is a desirable preliminary to large scale computation. Contains grounding in the basic operations of computation, approximation, interpolation, numerical differentiation and integration, and numerical solution of equations. Applications are to processes such as the smoothing of data, the numerical summation of series and the numerical solution of ordinary differential equations.

Encyclopedia of the Chemical Process Industries, by J. R. Stewart, The Chemical Publishing Co., Inc., Brooklyn, N. Y., 820 pp., $12.00.

Formerly called *Stewart's Scientific Dictionary*, the publishers have changed its name since the book is not a scientific dictionary but a reference book that treats the practical aspects of the industry: raw materials, processes, equipment and finished products of the chemical process industries in an encyclopedic form. The book also lists definitions of technical and scientific terms frequently encountered in these industries. The information has been collected for those actively engaged in this industry whether they handle research, engineering, production, control, purchasing or sales. For this reason it lists the manufacturers and uses of thousands of trade-name and trademarked products and can also serve as a chemist's buyers guide.

The Gordon Conferences

(Cont. from p. 41)

Chemistry and Physics of Metals, July 8-12; A. S. Nowick, chairman, E. S. Machlin, vice chairman. Sessions on: Visual Observation of Dislocations; Irradiation Effects; Properties of Dislocations.

Chemistry, Physiology, and Structure of Bones and Teeth, July 15-19; D. Harold Copp, chairman, D. Dziewiatkowski, vice chairman. Sessions on: Fine Structure of Bones and Teeth; Parathyroids and Regulation of Blood Calcium; Radiostrontium Metabolism; Effect of Hormones on the Skeleton.

Chemistry at Interfaces, July 22-26; Charles G. Dodd, chairman, Stephen Brunauer, vice chairman. Sessions on: Contributions of Solid-State Physics to Surface Chemistry; Monolayers; Capillarity and Fluid Flow in Porous Media; Calorimetry in Surface Chemistry.

Biochemistry and Agriculture, July 29-Aug. 2; A. G. Norman, chairman. Sessions on: Biochemistry of Soil-Plant Relationships; Biochemistry of Plant Growth and Growth Control; Biosynthesis and Postharvest Changes; Biochemistry of Action of Biocides.

Ion Exchange, Aug. 5-9 W. J. Sloan chairman, K. S. Spiegler, vice chairman.

Toxicology and Safety Evaluations, Aug. 12-16; Norton Nelson, chairman, John A. Zapp, vice chairman. Sessions on: Interpretation of Chronic Toxicity Studies; Physiological and Functional Measures of Toxicity; A Practical Approach to Dietary Carcinogens; Potentiation as a Factor in Toxicological Assessments.

Organic Coatings, Aug. 19-23; E. G. Bobalek, chairman, E. R. Mueller, co-chairman.

Glass, Aug. 26-30, T. H. Davies, chairman. Sessions on: Rate Processes in Glass; Viscous Flow; Dielectric and Mechanical Relaxation; Annealing of Structural Defects Induced in Glass.

Further information and applications for attendance of the Conferences may be obtained from Dr. W. George Parks, Director, Gordon Research Conferences, University of Rhode Island, Kingston, Rhode Island. Fees—which cover registration and room and meals for the Conference week—are $100 for industrial scientists, $75 for academic or government scientists.

The Director specifically requests that NO remittances accompany applications.

Reference Data:

HIGH FREQUENCY HEATING in its various phases is covered by a new house organ called Induction Heating Review. The first issue (February 1957) of 12 pages, carries four short features plus Departments devoted to New Equipment, Typical Applications, New Fixtures and Shop Hints, profusely illustrated with photos and diagrams. Published by Lepel High Frequency Labs, Inc., Woodside, N.Y.

DRYING AND CALCINING EQUIPMENT for research labs and pilot plants is illustrated and described in Bulletin No. 117. Included are: continuous rotary dryers and combination calciners and coolers, also rotary kilns and steam jacketed batch dryers. Available from The C. O. Bartlett & Snow Co., 6200 Harvard Ave., Cleveland 5, Ohio.

LABORATORY EQUIPMENT catalog, 28th edition, lists and illustrates apparatus, instruments, chemicals and glassware for industrial and educational labs. Write Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

POCKET-SIZE SLIDE CHART on machining stainless steels contains information on how to machine the popular grades. One side gives data on turning, milling, drilling, etc., while the other shows relative workability in various operations. Carpenter Steel Co., Reading, Pa.

FLEXIBLE COUPLINGS bulletin gives complete details on ½", ¾", 1" and 1½" diameter models with dimensions and graphs for lateral and torsional deflection. Offered by Naugler Engineering, Inc., 19 Madison Ave., Beverly, Mass.

SPECTROCHEMICAL ANALYSIS, its basic fundamentals and a bibliography of reference material are included in a 28-page illustrated brochure (CH401). This is the first of a series being prepared by Hilger & Watts, Ltd., English instrument makers. Copies obtainable from their American agents: Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

CHROMIUM-DIFFUSED LOW-CARBON STEELS as replacements for more costly alloys are discussed in a reprint bulletin which gives case histories, as well as information of this firm's process for increasing heat, wear and corrosion resistance of iron and steel parts. Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y.

FACE TO FACE

(Cont. from p. 22)

be sure that it's used. Technology that is not used might as well never have been created. It's not enough just to go out and accumulate all the knowledge you can because as time goes on, your ability to accumulate particular types of knowledge changes. For example, 15 years ago we were trying to understand the mechanism of alkylation, but we just didn't have the tools to analyze the specific isomers. We just couldn't understand the mechanism because we didn't know what we were doing. Now—15 years later—it is a simple matter because we do have better analytical tools. Had we been able to wait 15 years, we could have done that work in about a tenth the time that it took us earlier.

That's just the point I was trying to make. If that work had been done 30 years before by some undisciplined scientist who wasn't mindful of the commercial necessities of the thing, the information would have been on the shelf ready to go and the whole development might have moved ahead 15 years.

Well, it would have if there had been a need for the alkylate. In other words, you not only have to have the knowledge, you have to have a need for the product you are working on. It would have been of no use 15 years ago to know how to make the kinds of gasoline we have to make today, because the cars that need today's gasoline were not available either. Knowledge has usefulness not only in terms of its application but also in terms of time. That's my whole thesis. The fundamental knowledge should be ready when it's needed, the applied processes or products should be available when they are needed, and the commercial applications should be ready when they are needed. Time is the critical dimension.

Thank you, Mr. Reeves.

E. Duer Reeves, Executive Vice President of Esso Research and Engineering Company, introduced a work simplification program in the company about 2 years ago which has so far saved the company about 3 million dollars. He joined Esso in the early 30's, in 1947 was appointed a director and vice president, and in 1949 became Executive Vice President. He has been, for the past year, acting for the president who has been on leave to the Defense Department.

Advertising Index

HERE'S A BRIEF REVIEW OF LAST MONTH'S PRODUCT ADS FOR YOUR INFORMATION.

Economical Fabrication 74
This firm's design method achieves great savings in fabricating hard alloys.
A. O. Smith Corp., Milwaukee 1, Wis.

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5	15	25	35	45	55	65	75	85	95
6	16	26	36	46	56	66	76	86	96
7	17	27	37	47	57	67	77	87	97
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Nitroparaffines 77
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Industrial Chemicals Div., Commercial Solvents Corp., 260 Madison Ave. NYC 16

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The Bristol Co., Waterbury 20, Conn.

High Temperature Insulation 79
Two refractories solve the problem of insulation at extreme temperatures.
Refractories Div., The Carborundum Co., Perth Amboy, N.J.

Speed Reader 80
The Takcal unit analyzes jet performance with accuracy of ± 1 percent.
B&H Instrument Co., Inc., 3479 W. Vickery Blvd., Fort Worth 7, Texas

Right Arm of Research 81
These 1- to 8-channel oscillographic recording systems aid in dynamic analyses.
Sanborn Co., Industrial Div., Waltham, Mass.

Centrifugal Blowers 82
These units will solve heat problems in equipment in confined enclosures.
Barber-Colman Co., Dept. P, Rockford, Ill.

Fast and Pure 83
The arc melting vacuum furnace works fast on metals with high melting temperatures.
Consolidated Electrodynamics, Rochester Div., Rochester 3, N.Y.

For Temperatures to 2000° F 84
This muffle furnace is a complete self contained unit shipped ready for use.
Hevi-Duty Electric Co., Milwaukee 1, Wis.

High Intensity Sound 85
This firm's environmental sound chamber measures and produces high intensity sound.
Altec Lansing Corp., 1515 S. Manchester Ave., Anaheim, Calif.

Temperature Indicators 86
A complete line of dial thermometer types is offered by this company.
The Electric Auto-Lite Co., Instrument and Gauge Div., Toledo 1, Ohio

Box Furnace 87
This versatile, rugged one-unit furnace is ideal for laboratory use.
Lindberg Engineering Co., 2489 W. Hubbard St., Chicago 12, Ill.

Nefluoro-Photometer 88
Colorimeter, nephelometer and fluorometer are combined in this unit.
Fisher Scientific, 115 Fisher Bldg., Pittsburgh, Pa.

High Vacuum Equipment 89
Complete high vacuum systems for metallurgy are offered by this firm.
Kinney Mfg. Div., New York Air Brake Co., 3642D Washington St., Boston 30, Mass.

Shaker Systems 90
The Model 177 is one of a wide-band series designed for higher frequency operation.
The Calidyne Co., 120 Cross St., Winchester, Mass.

Power Resistor 91
These units have the utmost in stability plus high overload insurance.
Ward Leonard Electric Co., 12 South St., Mt. Vernon, N.Y.

Gets Things Done 92
This visual control system gives a picture of your operations at a glance.
Graphic Systems, 55 W. 42nd St., NYC 36

Lab Press 93
Featuring pressures up to 20,000 lb., this press includes many accessories.
Fred S. Carver, Inc., 1 Chatham Rd., Summit, N.J.

Ordering Aid 94
Your Tektronix Field Engineer will help you order the right oscilloscope.
Tektronix, Inc., Box 831, Portland 7, Ore.

Precise Control 95
These pressure sensing elements give precise control under all conditions.
The Bristol Co., Waterbury 20, Conn.

Relay Production Increased 96
With three plants to serve you, this firm offers finest quality relays.
Potter & Brumfield, Inc., Princeton, Ind.

High Torque Stirrers 97
These units are designed to handle simple or critical jobs with top efficiency.
Central Scientific Co., 1734 Irving Park Rd., Chicago 13, Ill.

Organo-Functional Silanes 98
These new silicone intermediates open up a new world to the organic chemist.
Silicones Div., Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N.Y.

Versatile Oscilloscopes 99
A whole family of DC- to- 5MC range oscilloscopes is housed in one unit.
Tektronix, Inc., P.O. Box 265, Portland, Ore.